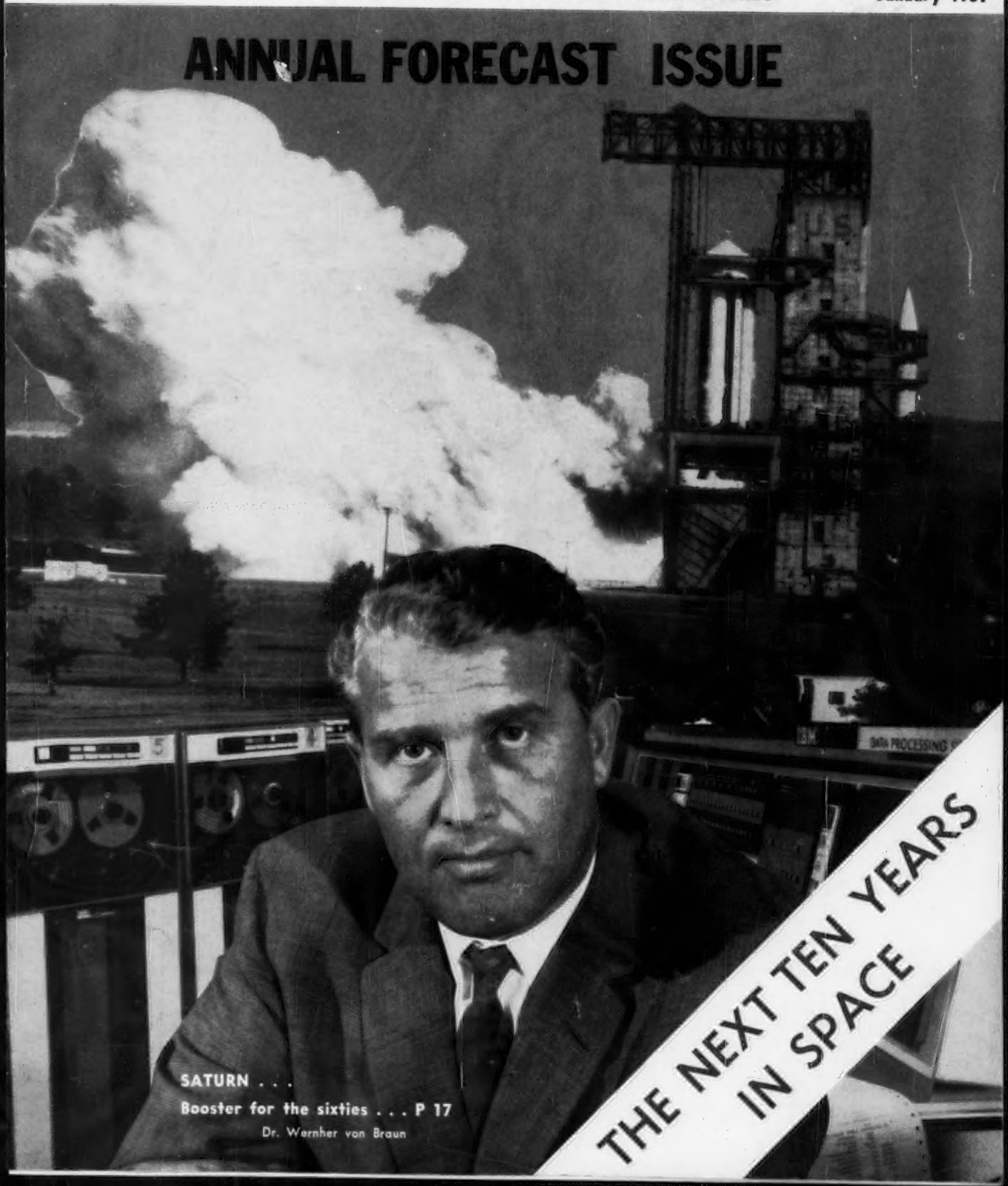
AIRCRAFT & MISSILES

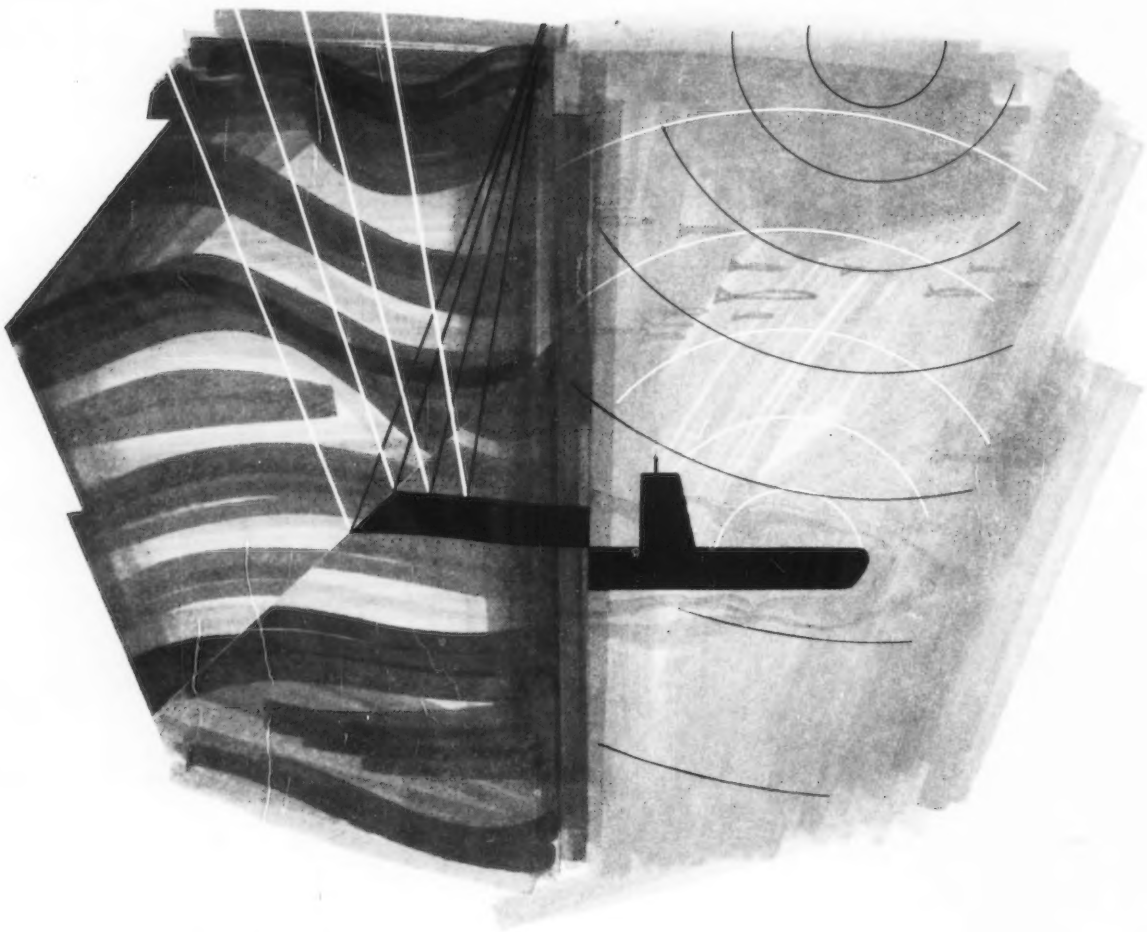
A Chilton Publication APPLIED ENGINEERING FOR THE AEROSPACE INDUSTRIES January 1961

ANNUAL FORECAST ISSUE



THE NEXT TEN YEARS IN SPACE

SATURN . . .
Booster for the sixties . . . P 17
Dr. Wernher von Braun



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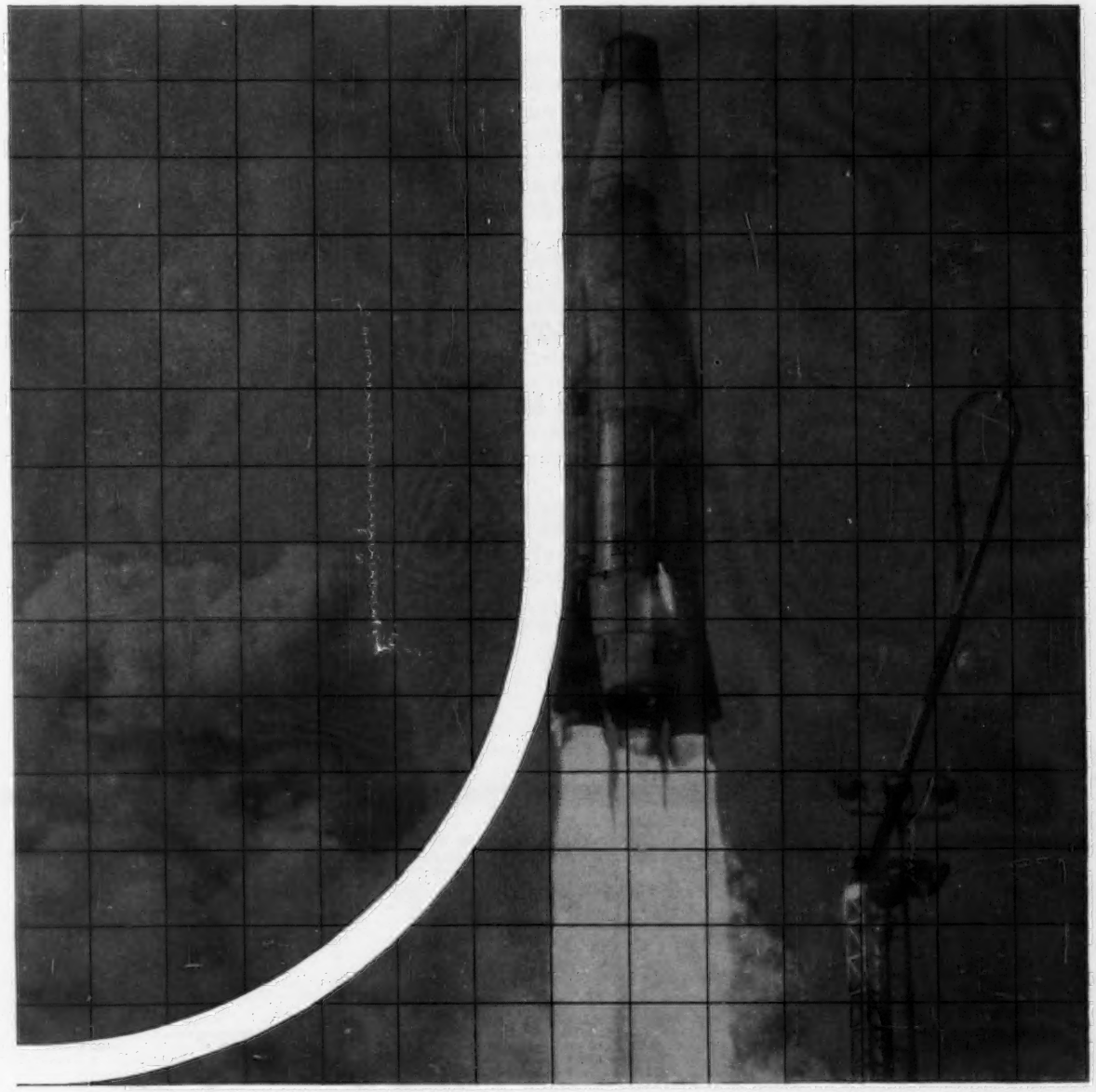

January, 1961 *Volume 4, Number 1*

AIRCRAFT & MISSILES

APPLIED ENGINEERING FOR THE AEROSPACE INDUSTRIES

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THE COVER STORY—Rocket power has been acclaimed the key to space flight since multi-ton Sputniks started orbiting. Approximately, Saturn, the vehicle that now looks like U.S.'s real hope for launching spectacular payloads is selected for the cover of this "Next Ten Years In Space" issue. Saturn development is in the hands of Dr. Wernher von Braun, director of George C. Marshall Spaceflight Center. See page 17.

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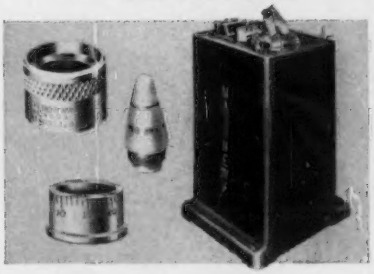

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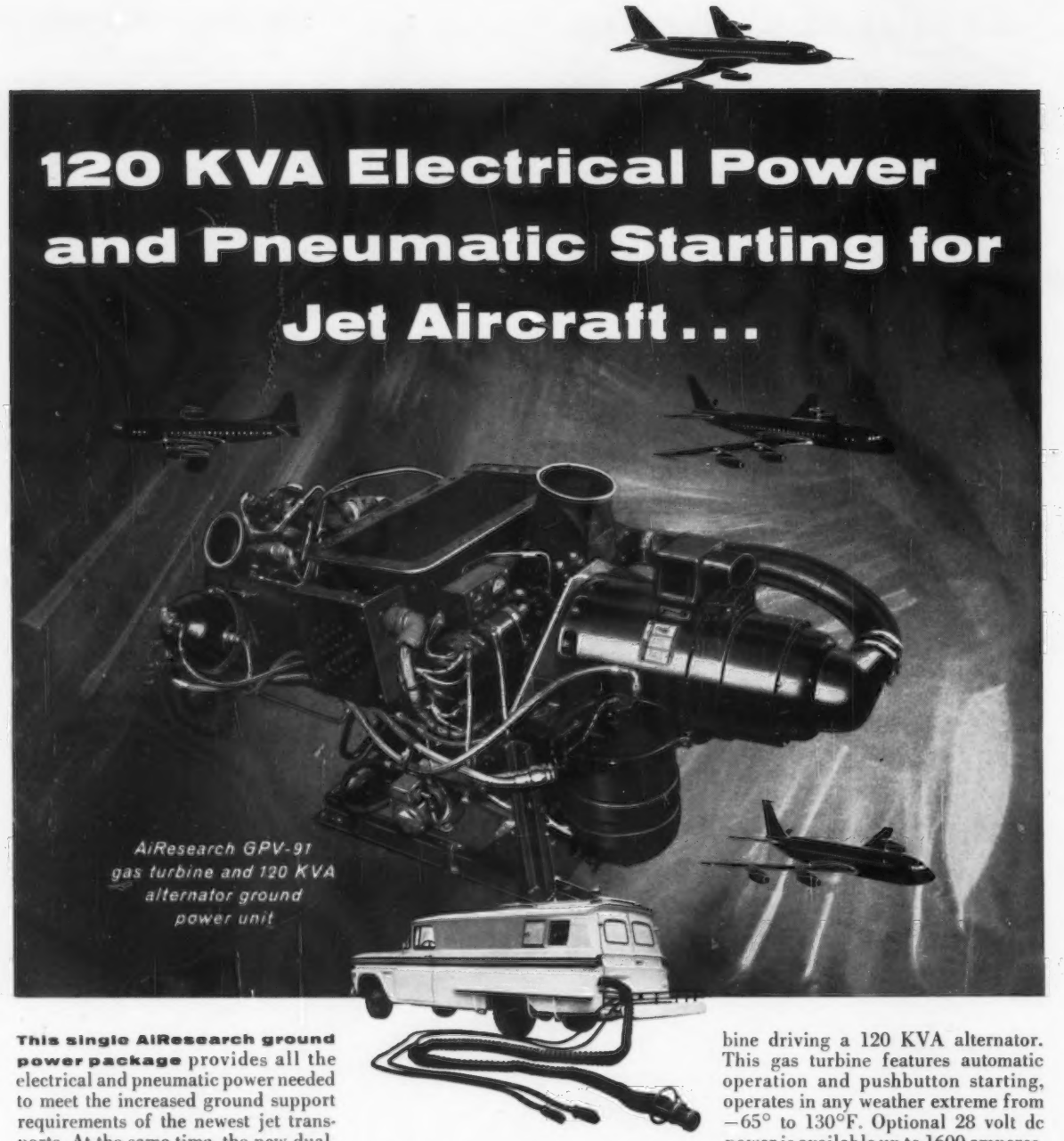

AiResearch GPV-91 gas turbine and 120 KVA alternator ground power unit

This single AiResearch ground power package provides all the electrical and pneumatic power needed to meet the increased ground support requirements of the newest jet transports. At the same time, the new dual-purpose GPV-91 results in a unit that effects considerable dollar savings over separate units to provide pneumatic starting and electrical services.

The 120 KVA power package doubles previous electrical output of support systems to supply all power for ground checkout and heating . . . and enables Freon refrigeration systems to operate at maximum capacity during the entire ground operation in hot weather.

The compact power unit consists of an AiResearch GTCP 85-91 gas turbine driving a 120 KVA alternator. This gas turbine features automatic operation and pushbutton starting, operates in any weather extreme from −65° to 130°F. Optional 28 volt dc power is available up to 1600 amperes.

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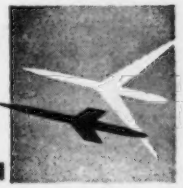

Looking Ahead

Three years ago, about this time, the first man-made object in space made its presence felt around the world. This shiny "pinpoint" traversing the skies reflected sufficient light to disperse the fog of complacency from our national thinking. The Sputnik became the symbol of an eloquent challenge in space. It further shed light upon the depth and breadth of earnestness required in our ideological struggle against opponents—militant politically as well as scientifically.

Aircraft & Missiles was born in this era of urgency, dedicated to implement the practical needs of the dynamic aerospace industries. The enthusiastic readership gained in the brief span of three years attests to the fulfillment of our prime editorial purpose. It motivates us, at the same time, to greater efforts toward editorial excellence. We are proud of the progress achieved by Aircraft & Missiles particularly because it coincides time-wise with the growth of our space effort. The span of accomplishments extending from non-existence to Tiros II, cover a substantial spectrum of effort; yet, a realistic appraisal would fall short without an awareness of the tasks lying ahead.

A & M will continue to meet the increased demand for practical data on the technology and materials of today for the design and development of the products of tomorrow.

Additional support will be given industry problems—even harder hitting than the 1960 "State Your Case" and "Challenge and the Progress" series which provided valuable facts toward the revision of certain government regulations. There will be new "Special Staff Reports" giving vital information to aerospace management.

Readers will find more items on electronics, materials, parts and components, production equipment, and available technical literature.

We look forward with confidence and optimism to the challenges of the future. We look forward with enthusiasm to the part our publication will play in keeping U. S. aerospace technologists the best informed in the world.

Tom MacNew
Editor

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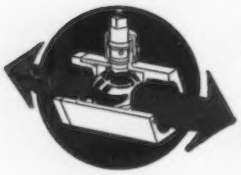
AS VERSATILE AS INDUSTRY ITSELF

The illustration below gives you a glimpse of the depth of application of the versatile Jamesbury "Double-Seal" Ball Valve.

For on-off, quarter turn, full flow, leakproof, maintenance-free operation, no valve can match the exclusive Jamesbury "Double-Seal" action.

We will welcome an opportunity to prove this statement, whatever your valving requirements might be.



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1. Standard flange with PC 50 operator.
2. Screwed end type.
3. 6" flange with ST 490 operator.
4. 6" flange for manual operation.
5. PVC screwed end type.
6. Screwed end with EM 25.
7. Screwed end with PC 50 operator.
8. 2" flanged valve.
9. PVC flanged valve.

MATERIALS:

Jamesbury "Double-Seal" Ball Valves are available in Types 303, 316 and Alloy 20 Stainless Steels, Carbon Steel, Bronze, Ductile Iron, Monel, Aluminum and PVC. Other materials on special order.

Interchangeable seats and seals are available in "Teflon", Nylon, Buna-N, Neoprene, Hypalon and natural rubbers.

Pneumatic, Hydraulic and Electric Motor Operators to fit Remote Control Requirements.

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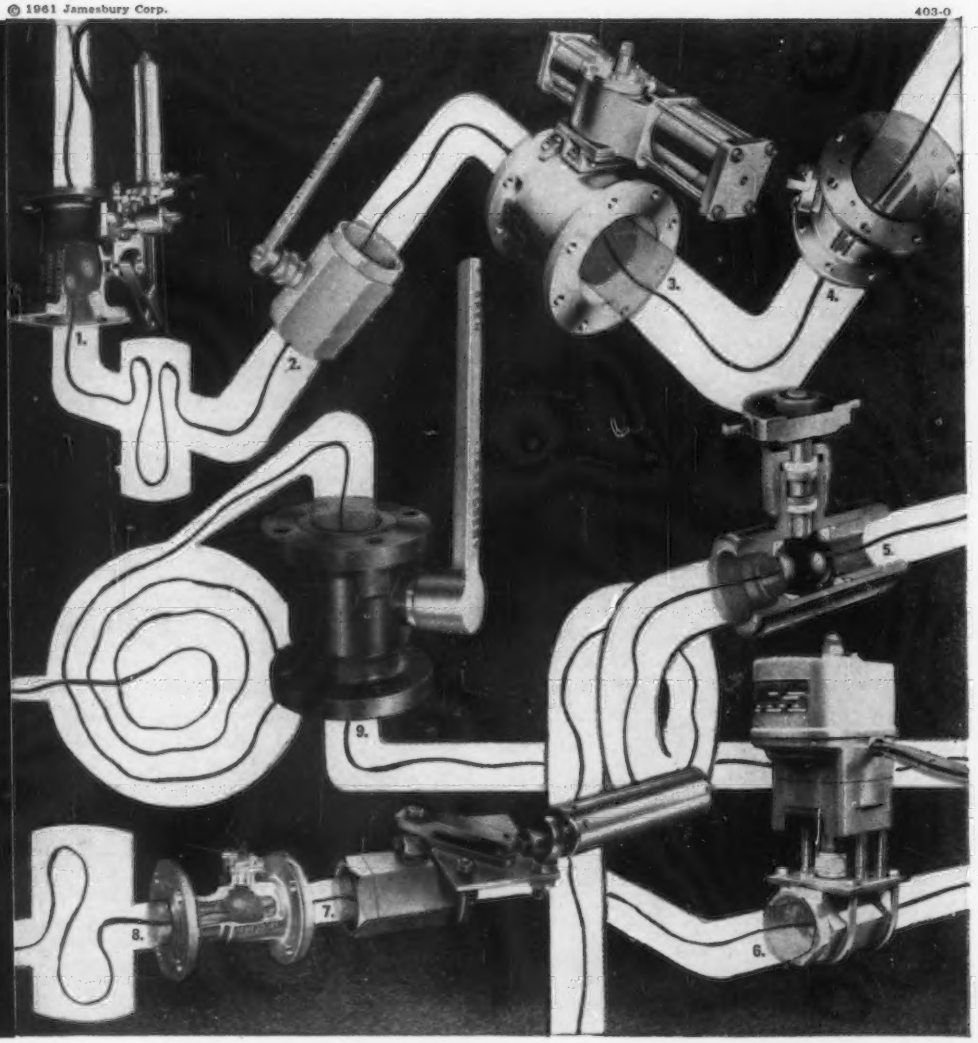
*10" and 12" on application.

*600# series on application.



Your Datebook

December 26-31
127th Meeting
American Assn. for the Advancement of Science
New York, N. Y.

January 9-11
Symposium on Reliability and Quality Control
Bellevue-Stratford Hotel, Phila., Pa.

January 9-13
International Congress and Exposition
Society of Automotive Engineers
Cobo Hall, Detroit, Mich.

January 15-18
13th Annual Convention
Helicopter Assn. of America
Cherry Hill Inn, Haddonfield, N. J.

January 16-18
Seventh Annual Meeting
American Astronautical Society
Sheraton-Dallas Hotel, Dallas, Texas

January 17-19
Winter Instrument-Automation Conference and Exhibit
Instrument Society of America
Jefferson Hotel, St. Louis, Mo.

January 23-25
29th Annual Meeting
Institute of the Aeronautical Sciences
Hotel Astor, N. Y., N. Y.

February 1-3
Second Winter Military Electronics Convention
Institute of Radio Engineers
Biltmore Hotel, Los Angeles

February 1-3
Solid Propellants Conference
American Rocket Society
Salt Lake City, Utah

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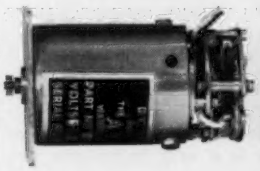
SIDEWINDER

TIME TO TRAVEL... in a bird, or elsewhere, this A. W. Haydon timing motor is unique. We married our successful Vanguard II sub-miniature DC motor, for power, to a tiny new version of our well known (and patented) chronometric governor, for precision. Result: it will drive miniature tape recorders, printed circuit commutators, potentiometers, and such things... and hold its speed to within ±0.1% of the speed you want, even if the shaft load, line voltage and ambient temperature vary widely. It weighs a mere two ounces and measures less than 1¾" x 15/16", yet delivers at least 30 ounce-inches of torque at 1 rpm. For full information on this #14600 motor, or any other sort of timing device, electronic or motor driven, just write.



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266 NORTH ELM STREET, WATERBURY, CONNECTICUT

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Reader's Orbit

Patent Infringement

. . . "We Tried To Do Business With DOD" (November) was read with great interest, since we have had similar experiences. In our case, this has involved procurement agencies actually becoming a party to patent infringement on articles which were developed independently, and entirely on non-governmental funds.

In each of two instances, an exclusive license had been granted to a manufacturer to whom original government procurement contracts had been awarded, including provision for royalty payments at usual nominal rates. In both cases, infringement by non-licensed competitors has subsequently been encouraged by procuring agencies. In several instances, the contracts went to such companies because of price differentials less than the amount represented by the royalty figures included in the licensees' cost structures.

One of our licensees has already instituted legal action jointly against the infringer and the procuring agency, in the Court of Claims, but we understand that it may require up to five years for a decision to be reached.

The second of these two instances is of particular interest and parallels the experience of the Airborne Research and Development Corp. The item involved was developed at the urgent insistence of personal equipment and safety specialists serving the test pilots of the aircraft industry of this area. As soon as it had been developed and proof-tested, with the generous cooperation of several airframe manufacturers, it rapidly became a standard item among this using group, and was considered a major step forward in enhancing chances of survival during ejection from high-speed aircraft.

Immediate procurement of this item was urged by safety specialists of the Air Force, but apparently because of an "N.I.H." philosophy, another A.F. agency spent about two years trying to develop an equivalent item. Ours was finally standardized by the Air Force, but only after it had already been standardized by the Navy.

At this time, I cannot unqualifiedly offer additional details in full, at least for publication, since neither we nor our licensees are as hopeful as Mr. Hahn seemed to be (according to your article) that revelation of such information would have no adverse effect on future business. However, if a sufficient number of similar experiences can be adequately documented and brought to the attention of proper authorities, there might be hope of correcting what seems to us to be a most inequitable situation.

I am in complete agreement with Mr. Hahn that this kind of treatment by the government is pernicious, especially when it involves small businesses with limited ability to engage in expensive legal battles; it can only tend to "dry up" sources of creativity which should be applied to problems of national interest . . .

H. P. Roth
United Tanks Inc.

Proprietary Designs

Would you please send to my attention a reprint of the article, "Vicious Procurement Practices . . .? DOD Talks Back," by G. C. Bannerman, in your September 1960 issue.

As a side comment, we are among those manufacturers who have been forced to make two sets of drawings: one, a set of manufacturing drawings for our own use and for the use of others who do not follow the government practice of demanding our proprietary rights; and the second, a set of drawings with all information deleted that would facilitate reverse engineering or completely reveal our design.

Although this is an expensive and time-consuming process, we have found no other means of preventing a complete give-away of our proprietary rights to the government.

George E. Meeker
Engineering Publications
B. F. Goodrich Aviation Products

Furnace Feat

We were pleased to see our furnaces listed with the other large furnaces in the country in the December issue. This is a very impressive list. You may have noted that we have the largest diameter furnace of all. We were disappointed to see that you have listed the length of this furnace as 22 ft when it is actually 32 ft . . .

Orrin G. Meyers,
Vice-President & General Manager
J. W. Rex Co.

Failsafe Editing

. . . must admit to having been misled by the substitution of "not" for "now" as complained about in Mr. Frank Catlin's letter to the Editors ("Not . . . Now," issue of December 1960) . . . In such an important usage, i.e., where the substitution of "not" for "now" wholly changed the meaning of the statement, reference to Murphy's Law would indicate a preference for the wording, "Now Bondcheck can detect stress cracks . . ." This follows the principle well known in aviation that reliability should if at all possible include consideration of preventive medicine approaches . . . I have long ago given up using the phrase "attitude control," for example . . . because the odds are no better than even that it will appear in print as "altitude control." If one realizes errors are inevitable, much can be done beforehand to minimize their effects by "Fail Safe" design.

S. B. Spangler
Vice Adm., USN, Ret.
Director of Research
The Garrett Corp.

Believe it or not "attitude control" came out "altitude control" in December issue. See Data Capsule, left column page 11 that issue.

More On Palomar

Re: Readers Orbit—The Strength to Move Mountains (A&M, Dec. 1960) . . . humbly call to your attention the fact that both Mr. Roy J. Cibulk and whoever wrote the "clarifying" reply were in error. A glance at the map will convince you that the peak where the 200 inch observatory is located, bears the name of Palomar Mountain, and not Mount Palomar.

Vollo Ebrok
Senior Engineer
Emerson Radio & Phonograph Corp.

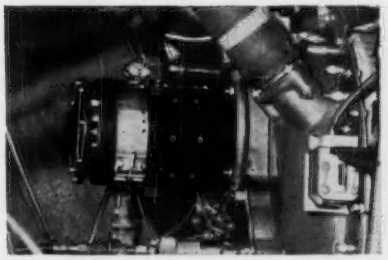
"MIDGET WITH A PUNCH"!

Bendix 16-lb. DC Starter Generator

Designed specifically to help the new lightweight gas-turbine engines get off to a quick start is the Bendix® type 30B56 DC Starter Generator. It provides 10 lb. ft. of torque at 3,000 rpm and will produce 30 volt/100 amp. DC power when driven between 7,000 and 12,000 rpm.

This "midget with a punch" requires a minimum envelope since it measures only 4.6" dia. x 8" long. It comes with round, square, or QAD flange and includes a fan to supply its own cooling air up to 20,000 feet.

If your needs are to start small gas turbines rated around 250 hp with a DC source, specify the Bendix type 30B56 and get 3 KW DC power, too. See us for details as related to your specific application.



Its small size makes the 30B56 Starter Generator ideal for use on the new small gas-turbine engines.

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THE Bendix CORPORATION

West Coast Office: 117 E. Providencia, Burbank, Calif. Export Sales & Service: Bendix International, 205 E. 42nd St., New York 17, N. Y.
Canadian Affiliate: Aviation Electric, Ltd., P.O. Box 6102, Montreal, Quebec

Canadair CL Forty Four, the largest Canadian aircraft, features the unique swing-tail to facilitate fast loading and unloading of the transport. Power for the aircraft is delivered by the Chatham low volume, low weight 200 ampere Y-Series transformer-rectifier.

Chatham Y-Series transformer-rectifiers furnish DC power to CANADAIR CL Forty Four transport

The Canadair CL Forty Four is the first plane designed with the unique hinged tail which swings back to give immediate and unobstructed access to the full cross-section of the fuselage for rapid loading and unloading of the cargo. The turbo-prop freighter, the largest aircraft built in Canada, has a payload of 33 tons and full transatlantic range capability.

DC power for the CL Forty Four is furnished by the revolutionary Chatham 200 ampere Y-Series silicon power transformer-rectifier. Canadair specified Chatham conversion equipment because they demanded unexcelled flight performance and reliability while restricting space and weight requirements to an absolute minimum.

Chatham Y-Series transformer-rectifiers—available in a range of outputs from 20 amps to 200 amps—are considerably smaller and lighter than competitive equipment with similar ratings. The 28VS200Y unit, for example, weighs under 17 pounds and occupies less than 310 cubic inches!

The ability to satisfy the toughest aircraft specifications with power conversion equipment that delivers unmatched performance and optimum physical configuration stems from Chatham's complete control over every step in design and production. Chatham even manufactures its own solid-state components so that designers are not limited by the "specs" of commercially available components.

Like Canadair, you can get the benefit of Chatham power conversion equipment know-how, too. Send today for Chatham brochure T-26A which describes power equipment that's immediately available. Or outline your needs and Chatham will recommend an original design to do the best job for you. Chatham Electronics, division of Tung-Sol Electric Inc., Livingston, N. J. TWX:LVTN NJ-489

CHATHAM, *...world's leading supplier of airborne power conversion equipment.*

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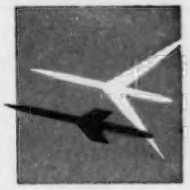
Data Capsule



SUMMARY OF MANAGEMENT TRENDS AND TECHNICAL DEVELOPMENTS IN THE AEROSPACE INDUSTRIES

MISSILES AND SPACE VEHICLES

Design

MERCURY SPACECRAFT may be controlled in orbit by any of four separate systems. These are: Automatic Stabilization and Control, rate command, fly-by-wire, and manual proportional control. Plans call for manual control on later Mercury missions. Designers of future spacecraft may thus gain valuable data on what an astronaut can and cannot do during extended weightlessness and high re-entry G's.

MERCURY RETRO-FIRING is planned as an automatic operation on initial missions. Automatic system is designed to compensate for expected torques about the major axes when a retro is fired. Mercury spacecraft's retro attitude is 34° with ±12.5° on pitch and ±30° on yaw and roll. During the subsequent re-entry at about —1.5°, oscillations and tumbling may occur. Automatic system or the astronaut must perform rate-damping.

HIGH TEMPERATURE BATTERY designed by Westinghouse makes use of "Austin Effect." Vitreous enamel on steel plates generates current between 300°C and 700°C. Battery might utilize "waste" heat from rocket nozzle.

Development

MANAGEMENT SURVEY, being conducted by the Air Force, will concentrate initially on Martin's Titan program. The Air Force wants to improve the management of complex advanced weapons systems. A group of procurement, production and audit specialists will examine production procedures and cost control methods.

PROJECT DEFENDER. Technical advice on rapidly-advancing anti-missile research will be furnished to ARPA by a special Technical Advisory Group from Stanford Research Institute, Lincoln Laboratories, Cornell Aeronautical Laboratory and the Willow Run Laboratory.

CENTAUR POWERPLANT. The LR-115 powerplant has been fired continuously on test for 5½ min. at Pratt and Whitney's Florida R&D Center. Centaur, slated for first flight this year, will have two LR-115's.

NIKE ZEUS GUIDANCE SYSTEM performed successfully in its initial flight-test at White Sands.

ADVANCED PROPULSION SYSTEM research will be carried out by new Douglas Aircraft subsidiary named Astropower.

DOUGLAS AIRCRAFT was awarded second generation Saturn space vehicle study contract. The $85,000 contract will be used for examining C-2 operational requirements.

F-1 PRELIMINARY FLIGHT-RATING TESTS are now scheduled to begin late next year. This 1.5-million-lb-thrust engine, expected to be available for launchings in the mid-sixties, will be clustered for the Nova vehicle.

SODIUM VAPOR TRAIL may aid in tracking space vehicles during re-entry. Such a marker, proposed by Lockheed Missile & Space Div., would be visible for many miles and would be hundreds of miles long.

RADIATION EFFECTS LAB, just completed by Marquardt, will be used primarily for Project Pluto. Lab will be available to industry for other nuclear work.

LONG LIFE FUEL CELL using chemical reaction between sodium, bromine, and mercury remains undamaged when short-circuited. Produced in Hoffman lab, its estimated lifetime is more than 10,000 charge-discharge cycles. Peak current density: up to 10,000 amps per ft^2 for one tenth millisecond.

X-15 is now ready for Air Force-NASA tests, having completed its third North American Aviation qualification test on Dec. 6. This test included running the 57,000-lb-thrust XLR-99 powerplant at 99 per cent of full power for a few seconds. XLR-99 was stopped and restarted three times during the flight.

EMERSON ELECTRIC has developed a system to trace mortar shells to their source after one round has been fired and detected. Firm sees missile defense possibilities.

SATURN BOOSTER is now in final assembly at the George C. Marshall Space Flight Center. A second Saturn booster is in first stages of assembly. Special barge for taking Booster to Canaveral has been completed.

Production

FIRST BOMARC B production model completed by Boeing. The 400-mile pilotless interceptors are to be stationed at six U.S. and two Canadian bases.

Procurement

SUPPLEMENTARY BUDGET REQUESTS are expected to be submitted by the administration this month. Increased funding will reportedly be sought for Minuteman, Polaris, and ICBM hard sites. Administration's Fiscal '62 defense budget may exceed $44-billion.

AIRCRAFT

Design

CONVAIR 990, which makes its first flight this month, has been designed with a supersonic wing including four speed capsules to minimize sonic shock wave and resultant drag. Wing is thinner and has more leading edge (39°) than any other transport. The speed capsules, pointed at each end, are on wing's upper surface and extend back of the trailing edge. The 990's engine pod allows large amounts of air to be drawn around the CJ-805 engine.

GRUMMAN ALBATROSS (SA-16) is being modified for ASW use. Amphibian will utilize MAD (magnetic anomaly detection) boom and ECM (Electronic Counter Measures) equipment.

ARRESTING SYSTEM for jet transports using a plastic-covered water basin has been proposed by Northrop Corp.

Development

VICKERS VANGUARD, called the first "second generation" turbine-powered airliner, is now entering service with British European Airways.

CARAVELLE VII is making its first test flights in the U. S. with CJ-805-23C aft-fan engines.

B-70 DEVELOPMENT CONTRACTS continue to be awarded. Convair will build the main wing box of stainless steel honeycomb. AiResearch Div., Garrett Corp., will provide the air data system. The Air Arm Div. of Westinghouse Electric Corp. will work on study requirements for the electromagnetic defensive system. Beech Aircraft will develop and manufacture the B-70 alert pod which furnishes power to the plane's six turbojets.

Production

FIRST PRODUCTION P3V is slated to roll out at Lockheed's California Div. this March.

DOUGLAS AIRCRAFT is converting 16 DC-7C passenger airliners into cargo transports. Average cost is $320,000 per transport.

NEW FIRM is producing executive and light aircraft in England. Known as British Executive & General Aviation Ltd. (BEAGLE), it was formed through a union of British Pressed Steel and Auster Aircraft Ltd. Engines for BEAGLE aircraft will be of American design, manufactured under license by Rolls-Royce.

BOEING will produce at least 80 of the three-engined medium range 727's. Eastern Airlines and United Air Lines will each take 40 of the planes.

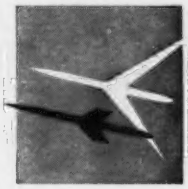
Procurement

PERCENTAGE OF DEFENSE PROCUREMENT OUTLAYS for airframes has decreased by a factor of two since 1954 and is projected to be reduced by another factor of two during the next ten years.

RIDDLE AIRLINES has ordered seven Armstrong Whitworth "Argosy" freighters. British manufacturer is pushing it as replacement for C-119's.

The Aerospace M-A-P

This capsule of business developments and trends is part of Aircraft & Missiles' Marketing Assistance Program, a research service to aid companies in the aerospace market.



Military Market In 60's

The military market is a fascinating one. This is the market that has doubled in the last decade. It is the market in which one-third of all capital goods are sold. It supports one-half of all R&D expenditures. It has the highest rate of product growth and product obsolescence. And is is a market marked for major growth in the 60's.

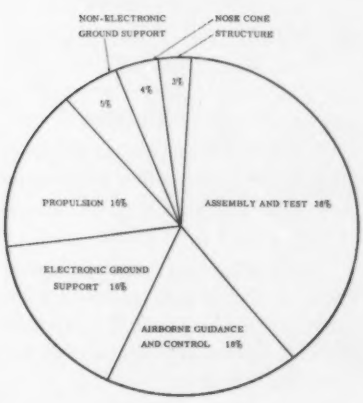
This is how things shape up for the next decade.

(1) The expenditures of DOD are estimated to rise at a slower rate than the GNP, from $41 billion in 1960 to $49 billion in 1970. Under existing tax rates this level of defense spending is consistent with large increases in non-defense programs, a balanced budget, and a moderate surplus available for tax or debt reduction.

(2) Within the military budget the R&D category will continue receiving an increasing share of the total. Over-all, approximately one-half of the military budget is likely to be devoted to procurement of hard goods.

(3) The shift in Air Force procurement from aircraft to missiles and space vehicles is expected to continue with a "cross-over" in 1963. Thereafter missiles and spacecraft will dominate this category.

CATEGORIES OF MISSILE PRODUCTION



(4) Expenditures for ships and submarines will once again replace aircraft as the dominant element of Naval procurement in the 1960's.

(5) Army procurement expenditures are likely to continue at present low levels with the bulk of their funds devoted to tactical and defense missiles.

(6) The expenditures of NASA are estimated to rise from less than $500 million in 1960 to $2.2 billion by 1967 and level off as existing programs phase out.

Cutting Up The Pie—In this switch to missile-type expenditures, it is interesting to take a look at where the money goes. In the heyday of aircraft, the lion's share of production costs went into airframes. But, in this changing market, precision assembly, endless testing, and systems development—largely electronic related — constitute the bulk of missile costs. The assembly and test work will continue to be done by the large aircraft companies who have become the prime contractors. Toward the end of the decade, as spacecraft begin operating, the major expenditures will be directed to integrating man into the space machine. This will involve extension and in some cases leap frog of the technologies developed by designers of today's sophisticated aircraft systems.

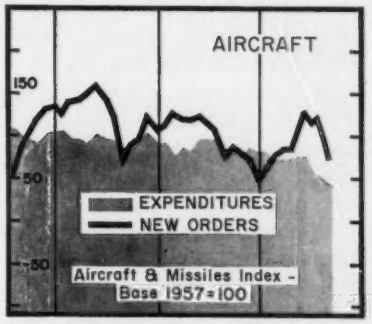
15-Year Outlook Sought For Test and Checkout

Design criteria for future Air Force automatic test and checkout systems will be recommended in a

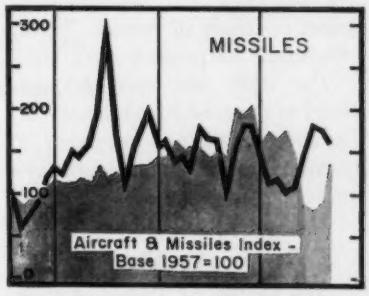
... continued on next page

DEFENSE EXPENDITURES AND NEW ORDERS

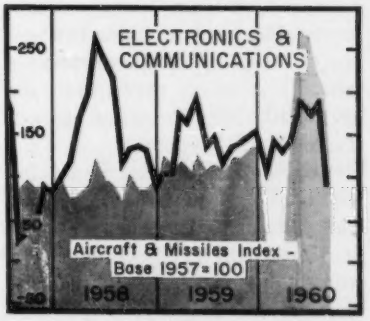
3 Months' Moving Average Index



Aircraft includes air-frames, engines, armament, electronics, and other government furnished equipment. Also included: special tools, test equipment, and ground handling equipment.



Missiles graph includes complete missile systems—armament, launching, guidance, control, boosters, sustainers, propellants, special tools, and ground handling equipment.



Electronics and communications graph is related to the following equipment: radar, electromagnetic equipment, computers, radiation airs, countermeasures, radiac and infrared, meteorological equipment, sonar, transmission or reception units, noise and interference detection devices, test equipment, spares, and related component equipment.

The Aerospace M-A-P

special study being conducted jointly by the Motorola Military Electronics Div. and the Douglas Missiles and Space Systems Engineering Dept.

Objectives of the Air Force study (SR-17530):

- Validate operational and maintenance requirements for test and checkout across the spectrum of future Air Force weapon systems for the period ending in 1975.
- Corroborate design criteria to provide a logical basis for insuring compatibility of future weapon systems and their associated test and check-out equipment.
- Determine feasibility of standardizing components of test and check-out equipment and the methodologies of test and check-out for future weapon systems.
- Determine the feasibility of designing an integrated multi-purpose automatic test and check-out system or family of systems for use with future weapons systems.

The study will also anticipate effects of new and revolutionary design concepts such as integrated, or micro-electronic circuitry and systems.

Business Moves

The Society of Technical Writers and Editors (STWE) and the Technical Publishing Society (TPS) have merged.

Goodrich-High Voltage Astronautics Inc. has established two new space research departments: a power conversion department and an electrostatic propulsion department.

Marshall Industries Inc. has formed a new subsidiary, Marshall Laboratories, to engage in the development and manufacture of electronic equipment for the missile and space vehicle industry.

The Gabriel Co. has integrated its Bohanan Div. in Compton, Calif. with its Rocket Power/Talco Div. in Mesa, Ariz.

Gyrotor Inc., new helicopter firm, recently opened offices in San Diego.

Precision Metalsmiths Inc., Cleveland, has just acquired Intricast, Inc., Loudonville, Ohio.

Astro-Fab, Inc. has expanded its operations to include specialty forming and joining and machining facilities for tantalum, molybdenum, and tungsten.

Thiokol Chemical Corp. recently formed a new division, National Electronics Div., with resultant liquidation of its wholly-owned subsidiary, National Electronics Laboratories Inc.

Technology Instrument Corp. announces change of name of its subsidiary, Acton Laboratories, to Technology Instrument Corp. of Acton.

The Siegler Corp. has formed Space Systems Technology Group to offer specialized technical services in missile and space systems design, development and test range planning.

Facilities

Southwest Research Institute is operating a high temperature facility producing temps close to 9800°F.

Wright Air Development Div. is now using a one-and-a-quarter million dollar electro-gasdynamic facility for testing flight performances of small-scale aerospace-craft re-entering the earth's atmosphere.

Space Technology Laboratories is constructing a 5,000-person space research and engineering center at Redondo Beach, Calif.

The Army is now studying effects of nuclear radiation on missiles with a linear electron accelerator producing a single high-intensity pulse of about 10,000,000 volts of gamma radiation. The Linac, operating at White Sands, was built by Hughes Aircraft.

Atlas Engineering Co. expects to complete its new Roxbury, Mass. plant next month.

Northrop Corp. plans to start construction this year on new facilities for its Radioplane Div. in Conejo Valley, Calif.

Wright Air Development Div. is now building the Free World's largest aerospace craft and missile sonic test chamber in Dayton, Ohio.

A. O. Smith Corp. will install an eight million-electron-volt linear accelerator in its Milwaukee plant this Spring. Use: high speed radiography.

Philco Corp. is undertaking a new $5,000,000 building program for its Western Development Laboratories in Palo Alto.

United Technology Corp. recently completed transferring the major portion of its Development Center staff to a 3200-acre mountain site near Morgan Hill, Calif.

Tasker Instruments Corp. now has a new headquarters building in Van Nuys, Calif.

Contracts

Grumman Aircraft Engineering Corp.—$70.1-million for additional production of the Navy's A2F-1 Intruder aircraft; $35.7-million for additional production of the carrier-based S2F-3 Tracker aircraft.

Linde Co.—$31-million to supply NASA with liquid hydrogen through 1966.

The Bendix Corp.—$26-million for continued development and evaluation of the Navy's Eagle missile system.

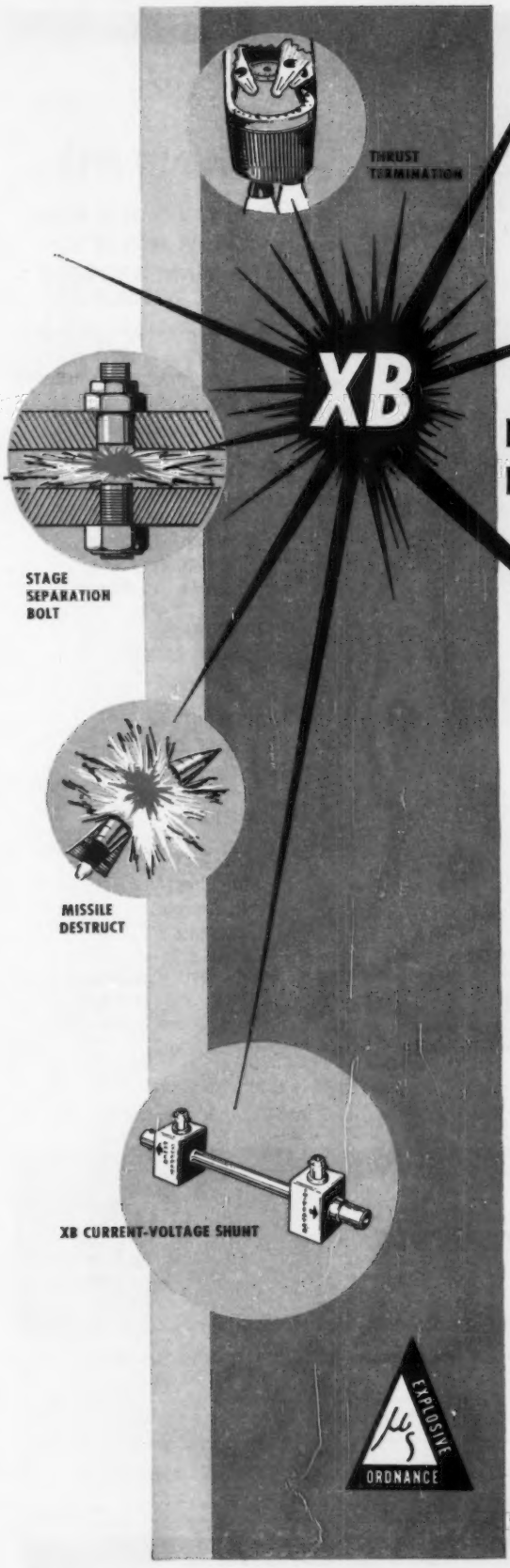
General Electric Co.—$22,677,000 to the Large Jet Engine Dept. for continued production of J79-5B turbojets for powering the B-58.

Northern Ordnance Inc.—$20.4-million for additional production of the Navy's MK 10 Terrier missile launching systems.

The Martin Co.—$20,428,000 for additional engineering services and production of Pershing.

Vitro Laboratories—$8-million to continue coordination and testing of Polaris weapons systems on nuclear-powered submarines.

Food Machinery and Chemical Corp. — $4,947,000 in total contracts for design and development of the vehicle and pod assembly for the Army's Mauler.



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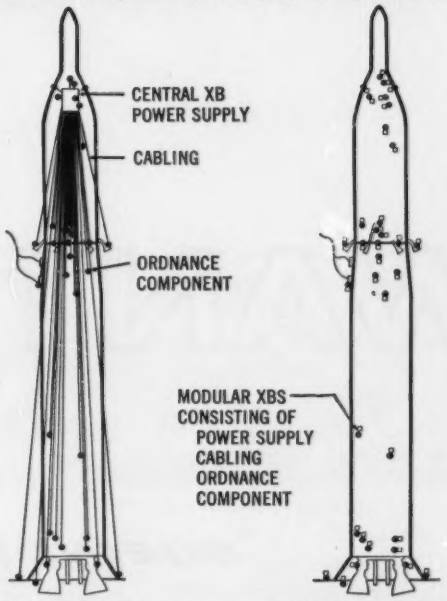
Comparison of Exploding Bridgewire System Concepts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Saturn... Booster For the Sixties

Hopes for man-in-space and planetary probes hinge on NASA's giant space vehicle; H-2 engine could boost 1st-stage thrust to 2.4 million lb

By John P. Kushnerick

A yellow circle, 22 ft in diameter, was painted on the wall of building 4707 at George C. Marshall Space Flight Center as a reminder of a job that lay ahead.

The circle was painted the day the last Jupiter IRBM went out the door in July 1959. It was painted by a group of tool engineers and represented a challenge of the 60's. It represented the diameter of a space vehicle that would eventually stand 230 ft tall, weigh 580 tons, and throw 45,000 lb into orbit. It represented the challenge of a development cycle unparalleled for such a vehicle, 10 months from tool-up to static test, two years from tool-up to launch, and only 11 firings and 3 years to operational status.

Behind this giant feat is forthright and proud Dr. Wernher von Braun, who brought his 115-man missile team to this country in 1945 (20 followed in 1948). They worked with scant funds and limited attention in Huntsville until the Russian Sputnik. Redstone was built,

DATA ON SATURN VEHICLES

Vehicle	Stage	Manufacturer	Designator	No. of Eng.	Thrust Total 1000 (lb)	Type of Engines	Engine Mfgr.	Fuel	Oxy.	Development Period
C-1	First	Marshall Spaceflight Center	S-1	8	1500	H-1	Rocketdyne	RP-1	O_2	1959-1964
C-1	Second	Douglas	S-4	4	60 to 80	LR119	Pratt & Whitney	H_2	O_2	1960-1964
C-1	Third	Convair	S-5	2	30 to 40	LR119	Pratt & Whitney	H_2	O_2	1961-1964
C-2	First	Marshall Spaceflight Center	Modified S-1	8	1500 to 2400	H-1 or H-2	Rocketdyne	RP-1	O_2	1963-1965
C-2	Second	Selection in 1962	S-2	4	800	J-2	Rocketdyne	H_2	O_2	1962-1966
C-2	Third	Douglas	S-4	4	60 to 80	LR119	Pratt & Whitney	H_2	O_2	1961-1964
C-2	Fourth	Convair	S-5	2	30 to 40	LR119	Pratt & Whitney	H_2	O_2	1961-1964

SATURN LAUNCHING SCHEDULE
C-1 VEHICLE

Vehicle Description	1961	1962	1963	1964
S1 + dummy upper stages	1	2	—	—
S1 + S4 + dummy 3rd stage	—	1	2	—
S1 + S4 + S5	—	—	3	—
Operational prototype	—	—	—	1

von Braun keeps rapid but sane pace for Saturn; Vehicle will be operational after 10 test shots

but few took their space talk seriously. Then the Washington crowd saw what von Braun had been saying for years; satellites were practical, we could and should explore space.

When Dr. von Braun went before Congress to present his case for an accelerated schedule for Saturn, he was offered more men, more overtime, more money, more anything to catch up with Russia. He couldn't go too fast now. But, in February 1960, von Braun wisely and coolly said, "I feel that to speed the program up much beyond the present funding rate would be very difficult if not impossible." When asked by a Congressman if it would be a waste of money to try to go faster, he answered simply, "Yes, sir." Parallel approaches to play it safer, yes. A speed up, no.

The Last Dollar — Von Braun and the entire NASA have drawn heavy fire from industry for this very attitude. Some feel NASA wants too much control, lacks a sense of urgency and guards its dollars too closely. But von Braun sees it this way, "The belief that all you have to do to get a job done is to give it to industry is as widespread as it is fallacious. Of course, we expect American industry to do most of the work on Saturn. Of course, we want to keep our in-house operation down to the minimum necessary. But of any $10 spent it is a good idea to keep $1 in the coordinating government agency in order to determine how to spend the $9 wisely . . . It is that $1 that we are having most of our difficulties over."

Booster Details — The booster on which U. S. places its majc. space hopes in the 60's will come alive first in a 3-stage configuration called C-1. A four stage version, C-2, will follow, and the ultimate 5 stage C-3 will probably be the end of the development line, if it materializes at all.

The main booster for all three is a cluster of 9 tanks and 8 engines. It stands 82 ft tall and has a 260 in. diam. The center tank is 105 inches in diameter and holds liquid oxygen. All outer tanks have a 70 in. diam. Four hold liquid oxygen and four RP-1, a low cut of kerosene. With few exceptions, tanks are 5456 aluminum alloy sheet. Sheets are contour milled to save weight in the flat condition, then rolled and joined by automatic fusion welding. Perforated stiffening rings are then spot welded in place. Tank ends are formed from chemically milled discs in a combination spinning-machining operation and joined by internal fillet welds.

The tank dimensions were chosen by von Braun with a keen eye for economy. Tooling previously developed for Redstone and Jupiter were put to good use on Saturn. Considerable modification of course was required, and some new tooling was needed.

TAIL SECTION is positioned in 24-ft tool ring. In succeeding operation large center LOX tank will be connected. Four inner and four outer thrust pads can be seen (arrows). Outer engines gimbal, inner engines are fixed.

SPIDER FRAME supports forward ends of propellant tanks and carries accessories for auxiliary power and booster recovery. All major subassemblies are preassembled, then moved to final assembly area. Tool ring stays attached through fabrication and shipping.

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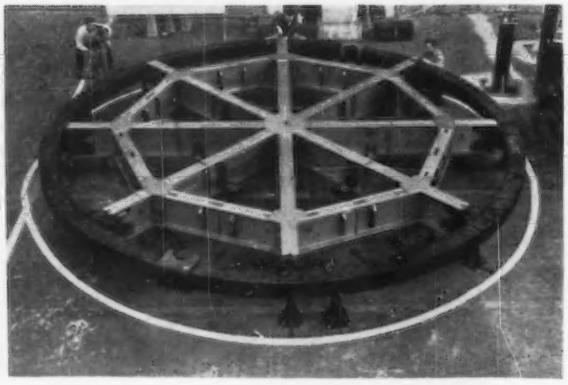
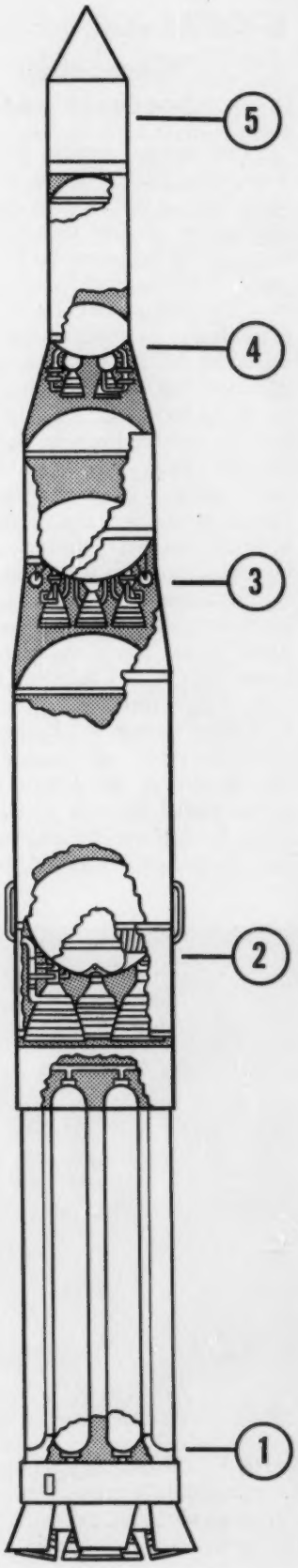


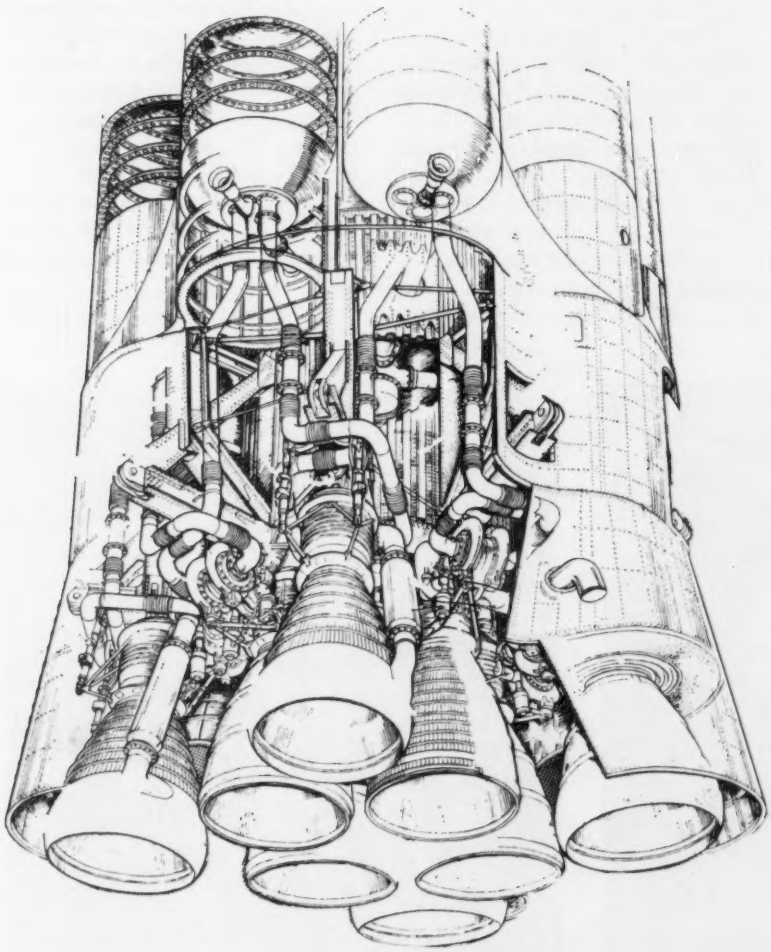
SATURN C-2 CONFIGURATION

1. Booster stage—S-1, 1.5 million lb thrust, (8) H-1 engines
2. Second stage—S-2, 800,000 lb thrust, (4) J-2 engines
3. Third stage—S-4, 70,000 lb thrust approx., (4) LR-119 engines
4. Fourth stage—S-5, 35,000 lb thrust approx., (2) LR-119 engines
5. Payload, 45,000 lb in low orbit, planetary probes, moon landing

Dimensions: Booster 256-in. diam; height 230 ft approx.



CUTAWAY OF SATURN BOOSTER



Original drawing from
FLIGHT
Revised by Aircraft & Missiles

"Cannonball" start on Saturn's H-1 booster engines produces peak thrust 0.5 sec after propellants hit injector

This tankage supplies the first stage with 750,000 lb of propellants. The aft end of each tank is attached to an eight legged thrust frame and barrel assembly. The engines are also secured to this structure. The forward end of each tank is attached to a circular spider beam assembly. All the LOX tanks are interconnected with each other, as are all the fuel tanks. This makes it easier to equalize loads during fueling and flight. The LOX tanks shrink about 2½ in. because of thermal contraction, so they cannot be rigidly attached to the fuel tanks. For this reason, the RP-1 tanks do not participate in the task of carrying thrust loads to the upper stages. About 60 per cent of the loads are transmitted by the 0.25 in. thick walls of the center tank.

Engine Growth — Engines to power the first stage booster are also economical and tested. They do not extend the state of the art much. Rocketdyne has uprated the Thor/Jupiter engine to 188,000 lb thrust, repackaged some components and called it the H-1. Together they will provide 1.5 million lb thrust.

An H-2 engine is already on the drawing boards for Saturn. By using "bootstrapping," H-2 will develop, from almost the same envelope and weight, 300,000 lb thrust. This would give the 8-engine cluster 2.4 million lb thrust. Saturn can absorb this growth; its structural safety is designed 20 per cent above the requirements of those usually used in big boosters. This safety factor is about the same as that of commercial aircraft.

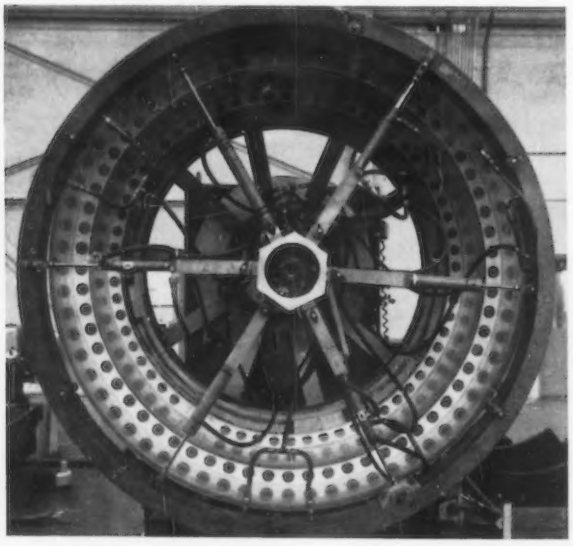
From their attach points on the eight-legged thrust frame, all H-1 engines cant outboard. Four engines on the inboard section of the thrust frame are rigidly attached, they cant at a 3 deg angle from the longitudinal axis of the missile. The other four engines are mounted outboard on the thrust frame. They are canted outward at a 6 deg angle. But these outer engines are gimballed and can swing about 10 deg to give roll and attitude control.

Start-Stop System — Starting system on the H-1 has been extremely simplified and thrust build up is rapid. Peak thrust is reached 0.5 sec after propellants reach the injector. This produces what is known as a "cannonball" start.

Mounted on Saturn, the engines are started in opposite pairs. A 250 millisecond delay between pair light-offs eliminates extremely unbalanced loads or the full 1.5 million lb thrust at once.

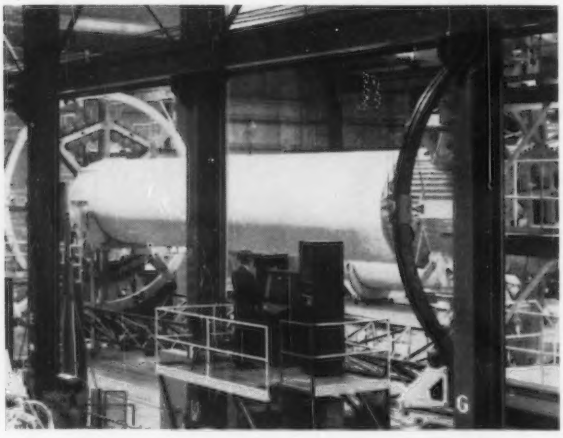
A single electrical circuit fires the squibs that start the sequence. A solid propellant charge (6 lb of ammonium nitrate) shoots a one second burst of gas into a semi-spherical body on the gas generator containing LOX and fuel. The gas generator is a small, film-cooled version of the main thrust chamber. Products of combustion start the turbopump and it hits 5000 rpm in 450 milliseconds.

Propellant pressures rise to 800



TANK WELDING rig has "serpentine design." It can be collapsed or expanded by pneumatic action. Provides good clamping action and precision fit. Stiffening ringframes are spotwelded in place.

IN FINAL ASSEMBLY, center tank is joined to spider frame (left) and tail section (right). Transducer readouts and push button remote controls are used for precision alignment. Controls also allow rotation of entire booster in cradle.



to 1000 psig and force open spring-loaded LOX and fuel valves. As the valves open, they rupture end diaphragms of the pyrophore container and release a charge of aluminum triethyl through the injector. The main fuel follows and is ignited. The entire sequence takes place in about 0.5 sec.

It is planned to hold the Saturn on the launch pad for about 3 sec after the firing signal while engines build up thrust. Sensor instrumentation will assure that all 8 engines are operating properly before hold-down mechanisms are released. Typical parameters measured will be chamber pressure, turbo-pump speed, and combustion stability. Should malfunction on any engine be sensed an automatic "shut down" sequence is triggered. This consists simply of firing solid propellant charges that stop the turbopumps. But if all engines reach 90 per cent of design chamber pressure, the vehicle will be released.

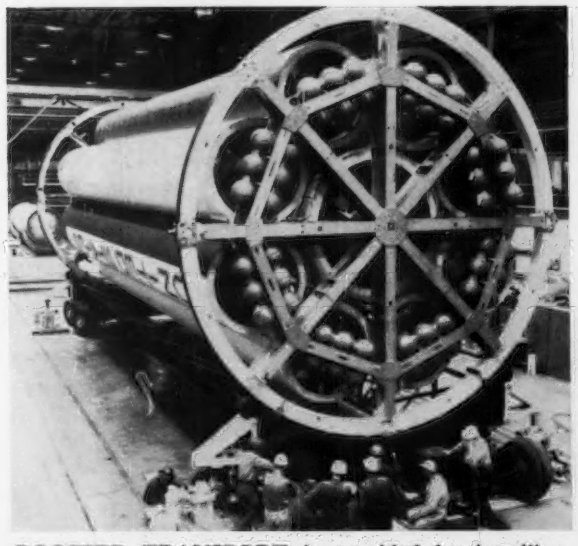
If one engine malfunctions, it can be shut down without affecting the mission if less than max payload is aboard. A second engine can be lost, if both are not gimballed engines, and some mission success expected. Three of four gimballed engines are necessary for proper steering.

There was early concern that the eight engines clustered in one housing would cause excessive vibration because of cross effects. However, tests to date show only a slight amplification of vibration energy levels in engine components over single engine levels.

Second Stage Trek—The Saturn C-1 will use a second stage now under development at Douglas. Because of its experience on Thor, Douglas is quite proficient fabricating 2014-T6 aluminum and selected this material for Saturn. The second stage has a 220 in. diameter, and incorporates four Pratt & Whitney LR-119 engines of 17,500 lb thrust each. Liquid hydrogen and liquid oxygen are the propellants. Pratt & Whitney manufacturers the engines in Florida, ships them to Santa Montica, Calif., where Douglas does the stage assembly. The complete stage is then shipped through the Pacific Ocean, Panama Canal, Gulf of Mexico, loaded on a barge and moved slowly up the Mississippi, Ohio, and Tennessee rivers to Huntsville. After check out and mating the second stage goes back on the barge for a trip down the Tennessee, Ohio, and Mississippi rivers, around Florida in the Gulf, and then up the Banana River to Cape Canaveral. The second stage engines wind up only a few counties away from their manufacture point after a 13,000 mile trek. The problems of insulating bimetallic couples of the second stage will not be easy. Nearly 10,000 mi of this long trip is over water.

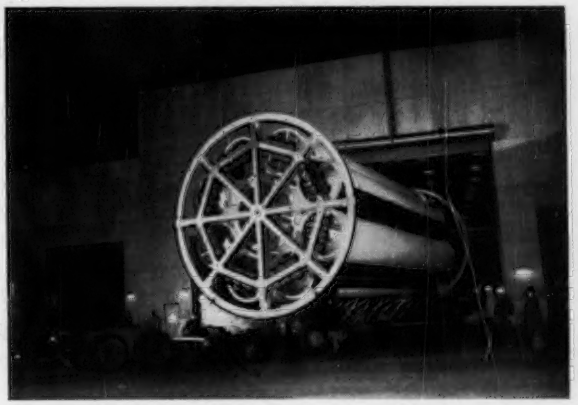
The third stage of the C-1 vehicle is being built at Convair. It consists of a modified Centaur vehicle with two Pratt & Whitney liquid hydrogen engines. The 120-in. diam stage will be made largely from stainless steel because of Convair's fabricating experience accumulated with Atlas.

Follow-on Saturns — The C-2 Saturn is the big one on which the real space hopes are placed. Von Braun has long talked of manned space stations, man on the moon, and Mars landings. This is the brute that will do the job. Will it put us ahead of Russia? Von Braun says, "it is bigger than anything they have now . . . but I consider it



BOOSTER TRANSPORT is provided by installing "walking gears" on the cradle in which the structure is assembled. Each wheel assembly consists of two pairs of independently braked and hydraulically steered aircraft tandem wheels.

TOWED TO TEST SITE, maximum allowable ground speed is 3 to 5 mph. Booster will be transported to Cape Canaveral by sea-going barge and tug. Nearly 60 per cent of Saturn launch cost is for ground support equipment.



Production pace of 20 per year possible after R&D shots are completed in 1964

very likely that they are busy at this very minute developing a rocket at least the size of Saturn."

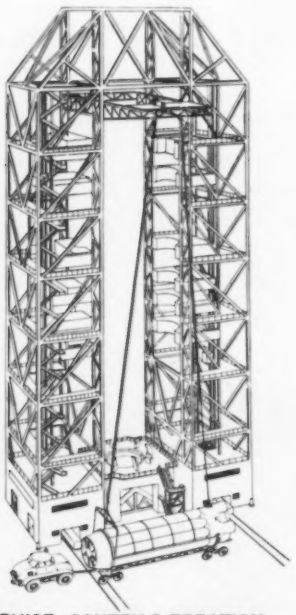
The C-2 has one more stage than the C-1. It will be a cluster of 4 liquid hydrogen engines called the J-2. Each will develop 200,000 lb of thrust and Rocketdyne has a $44 million contract to develop the engine in 4½ years. First models will have single-start capabilities, but changes in later models will allow multiple starts in flight.

The 5 stage C-3 is largely speculative in concept. It could use nuclear upper stages, it could use several J-2's as a new stage between the second and third stages of the C-2 vehicle. It could be many things. Or could not be at all, because Rocketdyne is also working under NASA contract on a 1.5 million lb thrust single chamber engine called the F-1. It will use a liquid oxygen/kerosene propellant system, bell-shaped nozzle, and regeneratively cooled tubular walls. Clustering four, or six of these engines in Saturn style and adding 3 liquid hydrogen upper stages would provide a vehicle that could soft land a 25 ton payload on the Moon. The vehicle is tentatively called Nova.

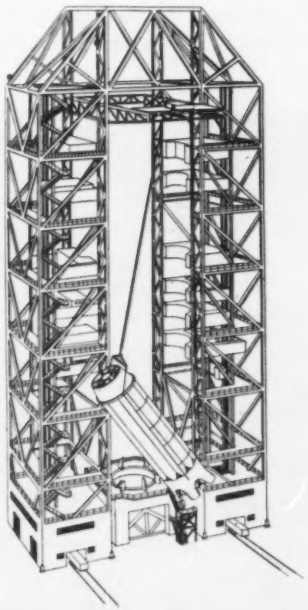
Production Rates—Before Nova, how many Saturn vehicles will there be? Von Braun doesn't want to over extend himself. He has now set what he considers a logical pace. A back up vehicle will be ready should anything go wrong in the operational shot in 1964. From then on he says, "After we pass the hurdle of R&D firings (and Saturn is generally liked) there is no reason in the world why with more funds we couldn't go up to a production rate of 10 or 20 a year. From then on it's just like putting a large aircraft in quantity production."

Key Personnel — Who are the key men now helping von Braun to speed Saturn along at Marshall Space Flight Center? He has two deputy directors. Dr. Eberhard F. M. Rees, is the deputy director for research and development; director for administration is Delmar M. Morris.

There are 10 divisions in the R&D organization. They are listed with their directors: Aeroballistics, Dr. E. D. Geissler; Computation, Dr. Helmut Hoelzer; Fabrication and Assembly Engineering, Hans Maus; Guidance and Control, Dr. Walter Haeussermann; Launch Operations Directorate, Dr. Kurt Debus; Research Projects, Dr. Ernst



SERVICE GANTRY & ERECTION (PHASE I)



SERVICE GANTRY & ERECTION (PHASE II)

TRACK MOUNTED GANTRY will be used to erect overall Saturn vehicle at Cape Canaveral. Structure has bridge crane suppporting two hooks at 40 and 60 tons capacity each. Hooks are attached to rear and forward section of booster respectively. Booster is tilted 45 deg from transporter cradle, lifted to pad height (Phase I) and positioned vertically (Phase II).

Stuhlinger; Structures and Mechanics, W. A. Mrazek; Systems Analysis and Reliability, Dieter Grau; Systems Support Equipment, Dr. Hans Hueter; and Test, Karl Heimburg.

Directors of staff and project offices are: Saturn Systems, Dr. O. H. Lange; Agena and Centaur Systems, Dr. Hans Hueter; Weapons Systems, Werner Tiller; Future Projects, H. H. Koelle; Technical Program Coordination, Dr. George Constan; Technical Services, David Newby; Management Services, V. C. Sorensen; Financial Management, Claude Stockton; Procurement and Contracting, Wilbur Davis; Management Analysis, Chauncey Huth; General Counsel, W. E. Guilian; Patent Counsel, John H. Warden.

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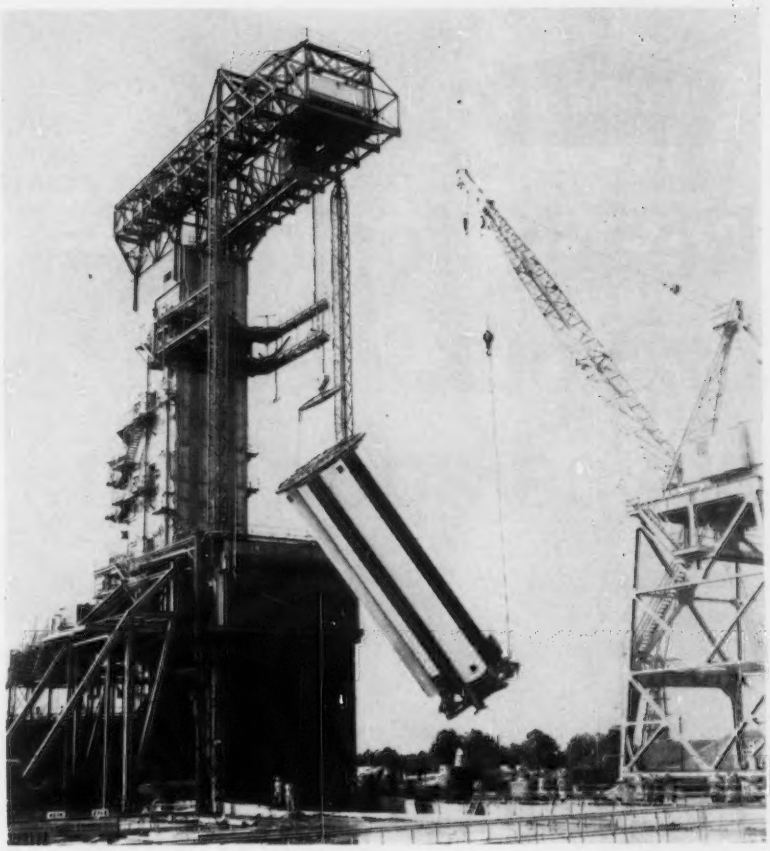
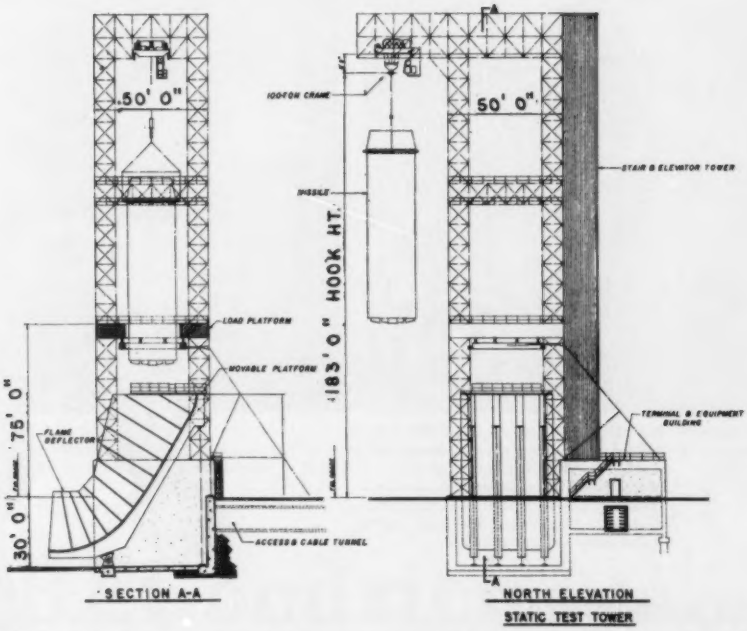
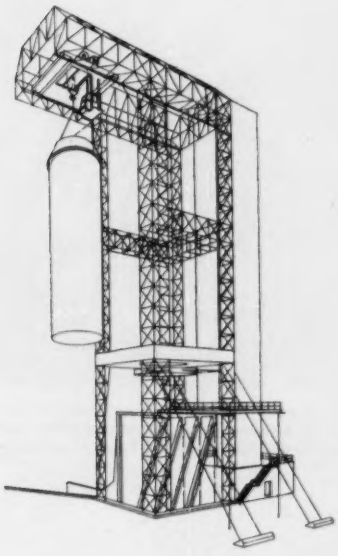


SATURN STATIC TEST FACILITY





STATIC TEST STAND at Huntsville can accommodate over 2 million lb of thrust. Stand was converted from original capacity of 500,000 lb. Tooling ring has been removed from rear section of Saturn booster. Engines were attached at test stand after booster was put in place.

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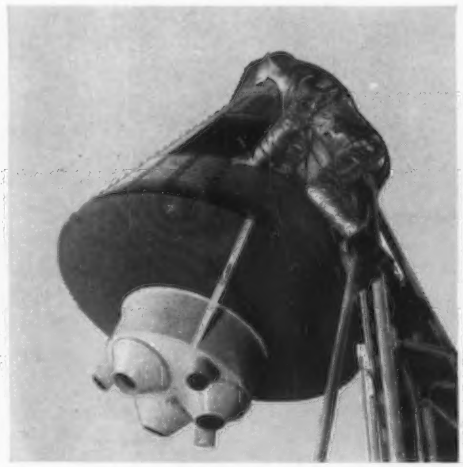
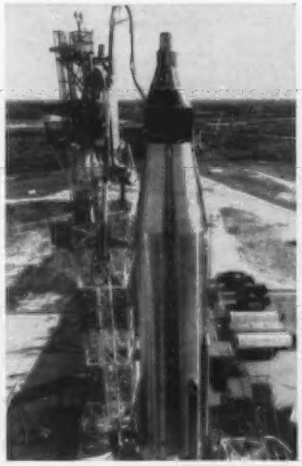


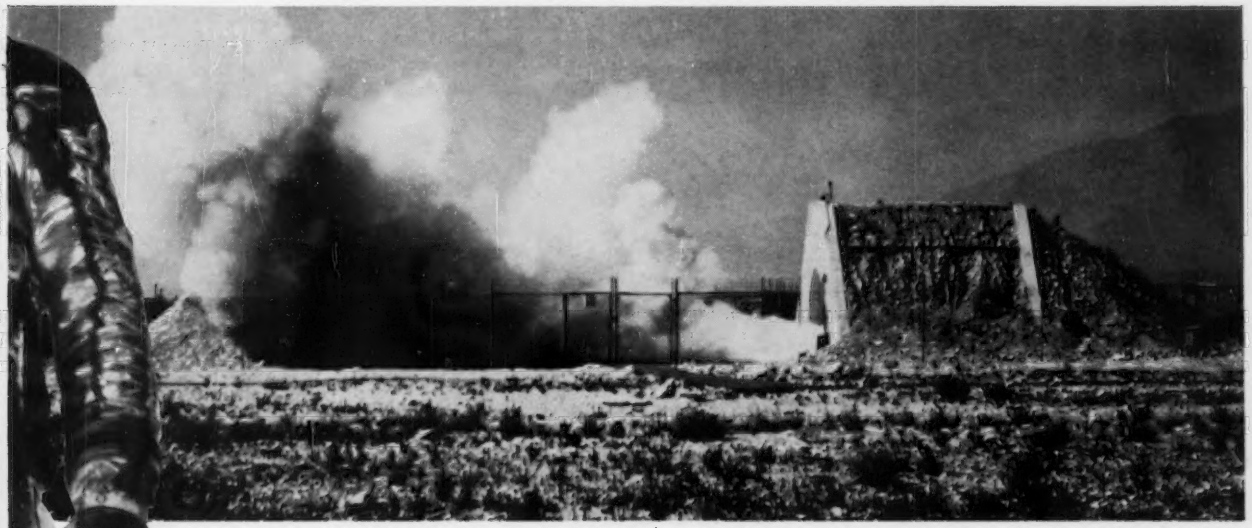
Mock-up of Project Mercury capsule, built by McDonnell Aircraft Corporation for the manned orbital flight program of the National Aeronautics and Space Administration.



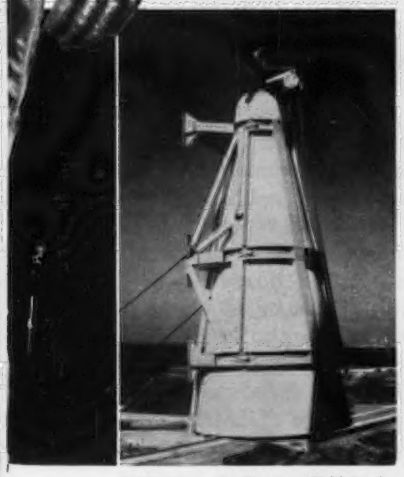
In "Big Joe" test launching, full scale model of Mercury space capsule was boosted 100 miles high atop this Air Force Atlas missile. Capsule was protected by a B. F. Goodrich laminated glass fibre and resin heat shield fabricated under subcontract to General Electric.

SUITING UP THE ASTRONAUTS The pressure suits to be worn by the Astronauts are now being fitted by B. F. Goodrich. This suit must maintain enough pressure to keep a man's blood from boiling, must provide air to breathe, must protect against searing heat. In the bargain, this pressure suit is light weight and flexible enough to allow free movement.

HIGH ENERGY SOLID PROPELLANTS This static test stand is one of 56 specialized facilities at the B.F.Goodrich solid propellant plant...currently processing and loading solid fueled motors of the LOKI, RTV and ASP types. BFG pioneered the development of the major polymeric binder-fuels now being used in the most advanced missiles.

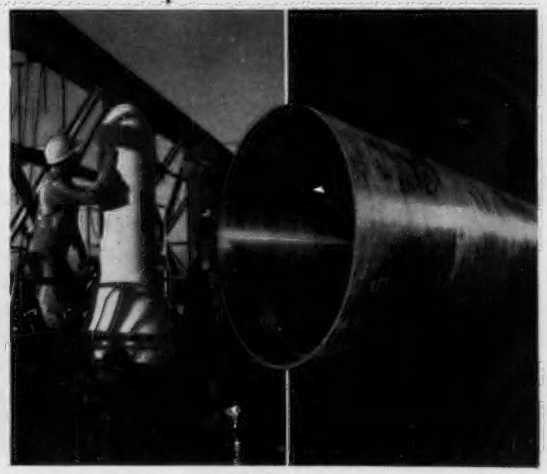


B.F.GOODRICH ABLATION SHIELDS ARE USED ON THESE U.S. AIR FORCE/GENERAL ELECTRIC SPACE VEHICLES



RVX-2 Re-entry/Recovery Vehicle, the largest ablation-type re-entry vehicle to travel full ICBM-range and be recovered.

Satellite Aeromedical Re-entry/ Recovery Vehicle for USAF Discoverer Program.



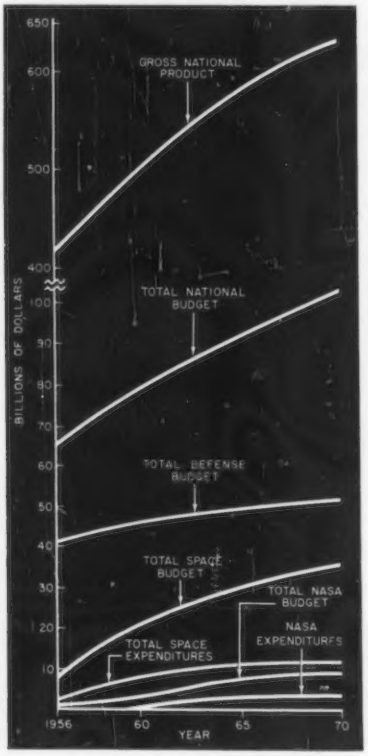
Mark-3, an advanced operational-type re-entry vehicle for the Air Force Atlas.

B.F.Goodrich aviation products

How Much For Space?

By Dr. Franco Fiorio

The Congressional Committee for Science and Astronautics estimates that $3.5 billion per year, for the next several years, will be spent for research and development in the field of space. An additional sum will be spent for hardware, about $500 million per year. Total expenditure—$4 billion per year.



The pace of $4 billion per year appears rather conservative in view of what happened in the past three years and of its extrapolation in the future.

Official statistics, available at the Government Printing Office, on Gross National Product, Total National Budget, and the Defense Budget were used to compile the graph on future space costs.

If the trends of the past five years follow for the next 10 years, simple extrapolation shows:

1. The amount of the Defense Budget is increasing, yearly, at a lesser rate than the Gross National Product (GNP) and the total National Budget, which have approximately the same growth factor. Percentage-wise, the U. S. will be spending less and less for National Defense in the coming 10 years, barring major war or a complete change in policy by a new administration.

2. By 1970 the total Space Budget (NASA and DOD, including ballistic missiles but excluding aircraft) and including pure and applied research in the space area, will be approximately $36 billion per year—27 for DOD and 9 for NASA. This is a conservative extrapolation, but substantially higher than the figures predicted by NASA in its 10 year plan.

3. The extrapolation of defense spending shows a budget of $52 billion in 1970. Theoretically, $72 billion is available if defense spending follows the same growth gradient as GNP and total Government spending. Thus, there will be $20 billion more to spend in 1970 either for DOD or NASA. One of the major tasks of the new President might well be the cutting and distribution of this particular cake. In any case, even the conservative estimates on the diagram for the total NASA budget, for NASA expenditures and for total Space expenditures are bound to be increased, if part or all of the $20 billion are going to be distributed.

With the acceleration of the race between East and West, at least $15 billion of those 20 will be used for additional space activities. This will bring the total yearly outlay for space by 1970 to about $51 billion including the $36 billion for the Space Budget. Each step of development will certainly bring about the need of more programs and more funds.

Based on a paper presented at 15th Annual Meeting of the American Rocket Society by Dr. Franco Fiorio, U. S. Liaison Officer of Italian Space Commission.

Profitless Prosperity

By Courtlandt S. Gross, President,
Lockheed Aircraft Corp.

From statements of President-elect Kennedy and others, it appears that defense spending will be stepped up in the next year by perhaps $2 or $3 billion. It may continue at this level, or even more, for the rest of the decade.

There will be a somewhat higher level of defense spending in the immediate future. This may sound like a golden bonanza for the defense business. Do not be deceived. It may turn out to be a period of greater business, but a tougher scramble for profits—a period of what we might call "profitless prosperity."

One problem—and one with which we can't find fault in principle—is a general concern by military agencies and congress with mounting costs. This is a continuing problem, but next year it will receive increased emphasis.

General Mark Bradley feels that many costs are overstated in incentive contracts and that improvements over targeted expenses too often come from this original overstatement rather than the increased efficiency to which we in the industry attribute these cost improvements. He believes some companies have set unreasonably low target figures on CPFF contracts—as a means of getting the business and then seeking payment for overruns of targeted figures. He thinks some of our "make or buy" decisions are open to criticism. He says some contracts the primes write with the subcontractors do not always guarantee the lowest costs. He thinks we could halve the number of sole source subcontractors.

Tighter control over costs is not only the ethical thing to do but obviously good business practice that in the long run is the most profitable. The high cost producer, one way or another, will be weeded out.

The defense industry will be subject to an increasing profit squeeze along with this cost cutting pressure. Profits resulting from legitimate economies will be suspect. Overruns will be questioned more closely. Renegotiation will hover above prime contractor and subcontractor alike, continuing to cut into profits.

In this matter of general cost tightening, many firms, perhaps for the first time, are coming up against cost disallowance criteria established by DOD for CPFF contracts. With the greater use of CPFF and price - redeterminable subcontracts in developmental programs, this matter of cost disallowances is going to be more widespread. Primes have the unenviable role of policing and requiring these disallowances. The practice of excluding certain ordinary business costs such as interest on borrowings is undoubtedly part of the general atmosphere of tighter control and less freedom for exercising business judgment.

In making sub-contract termination settlements, the primes are required to obtain clearance from the military on both the amount of settlement and the disposition of inventory. Only hope for relief seems to lie in legislative changes.

There are other ways, too, in which companies feel a tightening in government financing philosophy. One is in the funding of contracts.

Another pressure is for private investment in facilities, even though many of those needed are special purpose and hard to adapt to other uses.

In the last congress there were a number of efforts to add to the government restrictions. The principal move was defeated for the time being—the effort in H.R. 11207 to place subcontracting procurement within the framework of Small Business Administration control. Such legislation will saddle us with yet another regulation, yet another administrator, at a time when our chief trouble is that we are over-legislated and over-administered.

The struggle is not over. Forces are regrouping. This small business proposal or one like it will almost certainly be reintroduced in the next congress.

Net effect of all this legislation, these rules and practices, this hostility to fair and adequate profit from defense work, this encroachment upon the rights and principles of private enterprise is bound to make defense work less attractive. Imposition of excessive government controls is discouraging incentive.

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Guidance And Secondary Power Needs

JPL details systems and component development schedule to bring NASA's Ten Year Plan to reality

By W. E. Giberson, Chief,
Guidance and Control Div.
Jet Propulsion Laboratory

What do we need in guidance and auxiliary power for the next ten years in space? Based on NASA's announced Ten-Year Plan, Jet Propulsion views it this way.

Basic Ranger Hardware — The guidance, control, and power subsystems that will be used to impact a package on the Moon in 1961-62 with the Ranger, will also be used in the Mariner-Venus spacecraft as late as 1966. But, an horizon-scanner planet tracker for orientation of the vehicle toward Venus will be added. The planet tracking unit will lock on the geometric center of a "partially lit" planet at distances between 300,000 and 6000 kilometers. Either visual or infrared sensors will be used. This part of the development is not firmed since Venus probes extend the last half of the decade.

Approach Guidance—The next major increase in capability will be the addition of on-board planetary approach guidance. Midcourse guidance equipment already developed in Ranger will be augmented by new elements. These include accurate sensors for determining the angles between the centers of Sun, the planet, and reference stars (which may be as weak as third magnitude) to accuracies of 1 min of arc or better, at ranges between 3 million and 50,000 kilometers. Digital computation capability for matrix multiplication, square root extraction, and inverse trigonometric function will be required. Flights utilizing such equipment are expected in 1964. Simple means for locating and identifying various celestial bodies are also needed.

The capability to orbit and land on the planets will be the next requirement. Orbital injection guidance systems equivalent in complexity to simple satellite launch vehicle systems, will do the job. A horizon scanner operating only a few hundred kilometers above the surface of the planet is expected to be one of the prime components. Also, a versatile timing, sequencing, and logical control will be required to execute the scientific experiments of the spacecraft, as well as sensing and control operations for the orientation of antennas, etc., from the planetary surface.

For landing vehicles, the methods of sensing altitude and altitude rate and cross-velocity are needed. Need is greatest immediately for lunar soft landing spacecraft, and later, probably, in planetary landing operations.

In planet flights, there is a possibility that celestial, midcourse navigation and guidance requiring angular measurements of 5 sec accuracy, and more voluminous computations of the type mentioned above will be used. For navigation current emphasis is on position-measuring guidance schemes.

Attitude Control—Considerable improvement is needed in attitude

control actuation. Outstanding requirements are for long-life and high weight-efficiency. This points to the use of hybrid systems with conservative momentum-interchange devices (flywheels and reaction spheres) in combination with various nonconservative torquing devices such as mass expulsion or solar torque. Methods of reducing the weight of the nonconservative portion include raising the specific impulse of the working substance, and reducing the tankage weight.

The lifetime required of the spacecraft is 3 to 6 months. For orbital and landing missions, the lifetime can be expected to increase up to 1 year. For missions to the distant planets, preliminary information indicates that lifetimes of at least 2½ to 3 years will be required.

REQUIREMENTS—COMPONENTS AND DEVICES

Sensors—To meet the attitude control and guidance needs over the next half decade, sensors having approximately the accuracy shown in Fig. 1 will be required. For reference, the present performance of sensors in Ranger is indicated.

Dates shown correspond to the availability of a working prototype, which can be reproduced for flight use with only minor design cleanup. Although accuracies of 0.001 deg are shown, this does not imply that the entire spacecraft will be controlled in attitude to this order of accuracy. It is unlikely the spacecraft will be controlled to better than 0.05 deg. The high accuracies are required in guidance sensor subsystems such as gimballed star and plannet seekers and trackers which can be made independent of the exact vehicle orientation. Since the same sensor might be utilized for both guidance and control, the higher guidance performance requirements are indicated.

Unnecessary Complication—Schemes have been proposed for stellar identification which allow a great number of directions to be recognized by providing coverage over an entire sphere. Such schemes involve storage of "star maps" to be compared with observed patterns. Star catalogues would be compared with observed spectral characteristics. The ability to recognize many directions around an entire sphere introduces an unnecessary complication for missions within the solar system. A much simpler method is to acquire the Sun first, then get a complete coordinate reference system by identifying one other star direction.

Based on the best information available to JPL there are no sensor developments that require a true technological breakthrough in order to meet the requirements shown in Fig. 1. The reliability of existing sensors, is, however, far from adequate for the mid-60 flights, however.

Gyro Needs—Gyro performance requirements are shown in Fig 2. In the typical gyro applications of near future, stability will be an important design criteria. The predominant source of errors (when it is realized that acceleration effects will be minimal during normal operation phases) will be the restraint and reaction torques—sometimes referred to as fixed torques. These torques plus their variations in stability are of particular concern and should receive increased emphasis by industry.

Advanced inertial sensors such as the electrostatic supported gyro and the cryogenic gyro are of interest. It is estimated that performance in the region of 0.005 deg/hr with digital data readout will be useful in the 1963-1965 era.

The future need for acceleration sensors hinges on the introduction and utilization of electrical propulsion systems, and on component availability. Since neither can be accurately forecast, JPL has made engineering estimates of the future requirements. Low levels of acceleration acting for long periods of time can be expected. A sensing device having a dynamic range of 10^5 or better will be required. The lower bound of repeatability would be in the region of 3×10^{-9} g's.

Pulse torquing of the inertial instruments appears to be a desirable mode from the standpoint of accomplishing the digital computation and operation.

Future developments should be aimed at obtaining present day accuracies with simpler circuitry.

Actuators—The on-off cold gas mass expulsion system is the main actuation technique used in Ranger, others are shown in Fig. 3. The

FIGURE 1—SENSORS FOR GUIDANCE AND ATTITUDE CONTROL

Sensor	Measurement	Ranger	FUTURE NEED	
			Performance	Date
Sun	Angular deviation from line toward center of Sun.	0.1	0.01 deg. 0.001 deg.	CY-'62 CY-'64
Planet Sensor Altitude Control	Angular deviation from center of Radiation of a planet.	0.2	0.01 deg.	CY-'62
Planet Sensor Guidance	Angular diameter and deviation from true center of a planet. Long range.		0.01 deg. 0.001 deg.	CY-'62 CY-'64-'65
Horizon Scanner	Angular diameter and deviation from true center of a planet. Long range.		0.1 deg. 0.01 deg. 0.001 deg.	CY-'64 CY-'62 CY-'64-'65
Star	Angular deviation from a star.		0.01 deg. 0.001 deg.	CY-'62 CY-'64-'65
Gyroscope	(1) Short-term reference during commanded turns of spacecraft away from celestial references. (2) Angular rates of turn.	0.2/hr	0.001°/hr	CY-'64-'65

FIGURE 2—GYRO PERFORMANCE REQUIREMENTS

Characteristics	REQUIRED PERFORMANCE		
	Present	1962	1964
Mass Unbalance	.2°/hr/g	0.1	0.05
Mass Stability	.2°/hr/g	0.1	0.05
Reaction Torques	.7°/hr	0.2	0.1
Reaction Stability	.5°/hr	0.05	0.01
Restraint Torques	.1°/hr/mi	0.05	0.01
Restraint Stability	.1	0.05	0.01

Plans for next decade in space show need for better computers, nuclear generators

Ranger components are simple and moderately well developed. Linear or semi-linear flow control type valves having leakage rates in the region of 5 cc/hr or less in the off position and flow linearity of 20 per cent or better are desired. Over the long term, it would appear that reductions in the limit cycle and leakage are required. The use of hot gas mass expulsion systems is indicated around the middle of the decade. Hot gas pulsed systems having an impulse per actuation of 0.005 to 0.01 lb-sec and an integrated thrust of 0.5 to 1.0 lb appear attractive if the reliability required can be obtained. A throttleable system with a thrust range of 0.01 to 1.0 lb and a minimum burning time of one second appears useful around 1965. Fig. 3 shows JPL's estimated requirement for momentum interchange devices.

Two additional items relate to spacecraft actuation requirements: (1) digitized angular pickoffs and (2) special boom or articulated platform actuation devices. Digitized pickoffs having an accuracy of 20 to 30 sec of arc over 360 deg are required in the next few years for such items as optical and inertial sensors. The Accuracies approaching 2 to 5 sec of arc are desired in the long term. The pickoff device should be very simple, highly reliable and physically small. Presently available devices are complex and/or physically too large and generally require too much peripheral equipment.

Actuation devices for moving articulated assemblies having the following characteristics are required within the next five years:

- Output torque—5 to 10 ft-lb
- Output rate—1 to 5 RPH
- Weight—2 to 3 lb
- Input power — 1 to 3 watts when actuating
- Actuation technique—simple stepping action preferred

Requirements can probably be met with existing techniques, but considerable improvement in reliability and long life operation in the space environment is required before they can be applied.

Computers — During the next ten years, spacecraft computers will be needed for three different classes of problems. Beyond this time, all computations may be accomplished by a single spacecraft computer.

The first type of computation is that necessary to solve the navigation problem itself. This will be a relatively long computation without severe speed requirements.

FIGURE 3—ATTITUDE CONTROL ACTUATION

Technique		Force Characteristic	Useful Torque Range, Ft-Lb	Utilization	Application
Mass Expulsion	Cold Gas	I_{sp} = 80 sec	0.001 to 25	1960-1962	Complete System used in cruise mode
	Hot Gas	I_{sp} = 200 sec min 275 sec desired	0.01 to 30	1962-1964	Reset momentum device or complete system
	Vapor Pressure	I_{sp} = 80 sec	0.001 to 0.1		Reset momentum device or complete system
Momentum Interchange	Reaction Wheels	—	0 to 1	1962-1964	With auxiliary reset mechanism for trim mode
	Reaction Sphere	—	0 to 0.3	1962-1964	
Solar Pressure (Near the Earth's Orbit)		10^{-7} lb/ft^2	To 2 x 10^{-5}	1964-?	Reset momentum device

Second, is the storage and processing of scientific data. A large part of this work will take place during the terminal phases of the mission. High-speed computation will be needed, eventually in the megacycle range. Storage capacities of a million bits are foreseen within two years and later systems will need to be much larger as the number of experiments increases.

The third area of use is control of the spacecraft and its experiments. This may vary all the way from control of the guidance sensors and spacecraft maneuvering, to control of advanced vehicles for exploration of planetary surfaces. Since the environment is either not known or subject to wide variation, the techniques applicable to adaptive control systems need to be developed to implement these latter estimated requirements.

The spacecraft must operate unattended for periods of time which will eventually reach several years. Although improved reliability is of importance throughout the entire electronics field, it is critical for the spacecraft computer because of the large number of components in the machine and the fact that a single error early in flight could abort the entire mission because of the sequential nature of the calculations.

Component Reliability—In the development of new components, the emphasis should be on reliability. The microminiature semi-conductor techniques will be useful from the size, weight, and power consumption standpoint but may be used only if they can be developed to a reliability greater than that of present day regular size transistors.

All-magnetic circuits appear promising for guidance calculations particularly if the power requirements can be decreased. Present materials require excessive power in the several-hundred-kc/sec clock range. The advent of nuclear power sources will both reduce this limitation and make these devices even more attractive since they are probably more radiation resistant than semi-conductors. A high density storage system of several million bits

capacity is needed within five years. A random access memory as well as a sequential memory will be needed to satisfy the control problem which will ultimately require high speed computation. The data storage may reach 10 million bits by this time.

Shift In Emphasis—Techniques should be developed to enable the computer to detect errors and correct them, either by rescheduling the calculation or by switching out defective circuits and replacing them. Such techniques require a shift in emphasis from present day research and development which is largely aimed toward rapid localization of faults so they can be repaired by a maintenance man.

An example of component development needed is in the area of magnetic drums. A typical drum required for a spacecraft navigation computer should have a 100,000-bit storage capacity. Steady-state power requirements should be less than 5 watts. All parts of the drum system, heads, bearings, and coating must have a high (99 per cent) probability of an error-free running time of a year in a vacuum greater than 10^{-8} mm of Hg. The drum system must withstand the launch environment with regards to vibration, shock and temperature and the non-operating sterilization temperature.

Secondary Power—Power systems in spacecraft during 1961 and 1962 will make use of photovoltaic cells, primary batteries, and static converters and inverters. As shown in Fig. 4, the unregulated power requirements during this period will be about 160 watts in space; regulated power outputs will total about 100 watts. It is expected that this type of power system will also be used during the 1963 and 1964 missions, with the possible addition of secondary batteries or fuel cells. Power levels desired during 1963, 1964, are estimated to be 400 watts unregulated and 240 watts regulated.

The space missions of 1965-1970 will need a continuous unregulated power capability of about 2500 watts. Photovoltaic sources do not presently appear feasible for this amount of power due to their high cost. Solar or nuclear powered thermionic or turbine generators appear considerably more attractive for this application. Solar thermoelectric systems may be useful where the advantage of the ultralight weight more than offsets the disadvantage of the additional collector area. Large solar collectors, however, pose rather severe constraints upon the spacecraft design from the points of view of restricting scientific instrument viewing angles and of requiring continuous and accurate attitude control throughout flight. In addition, systems operating from solar power require fairly radical changes in order to accommodate the large variations in solar flux available for various interplanetary missions.

The majority of the effort expended in the development of photovoltaic cells should be directed toward increasing their efficiency and reducing their cost. (Fig. 5). It is expected that cost will have to be reduced by a factor of about 5 during the next 5 years in order to be competitive with other components except possibly for very low powered systems.

Batteries—Weight reduction of both primary and secondary batteries should be the chief objective during the next few years. Effort should be devoted to increasing the life of the cells, particularly with regard to primary batteries, in order to permit the fulfillment of long duration missions.

It is expected that fuel cells will not be available for space missions prior to 1963-1964. The non-regenerative cells should be capable of about 150 watt-hr per pound by this date in order to be competitive with primary batteries. The corresponding capability for regenerative cells is about 50 watt hours per pound.

Secondary batteries should be improved with regard to charge-discharge efficiency in order to ease power requirements for orbiting missions. (Fig. 5)

Emphasis should be placed upon reducing the weight and cost and increasing the reliability of static inverters and converters. Efford should also be devoted to reducing the noise and transients produced by these units.

Development of thermionic diodes should accentuate the extension of operating life to many months and eventually years. Improvement in efficiency, power density, and producibility are other important considerations.

Increase in efficiency appears to be the major factor in improvement of thermoelectric elements.

◆

FIGURE 4—POWER-WEIGHT REQUIREMENTS

Date	POWER, WATTS		WEIGHT
	Unregulated	Regulated	Pounds
1962	160	96	140
1964	400	240	250
1966	2500	1500	500

FIGURE 5—VITAL STATISTICS OF POWER SYSTEM ELEMENTS

	Available	Desired
Photovoltaic Panels		
Watts/lb	4	6-7
Efficiency (in space)	9-10%	15%
Batteries—Primary		
Watt-hr-lb	50-80	100
Stand by life-days at 80° F	30-60	150
Batteries—Secondary		
Watt-hr/lb	5-20	20-50
Charge—discharge efficiency	60-75%	70-85%
Life—Cycles (90% discharge)	200 approx.	500
Inverters and Converters		
Watt/lb	3-7	7-15
Efficiency	70-85%	80-90
Regulation	1%	0.1-0.57%

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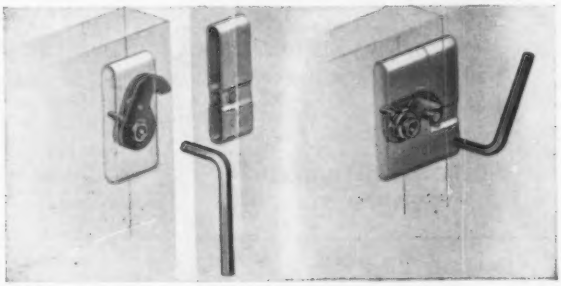

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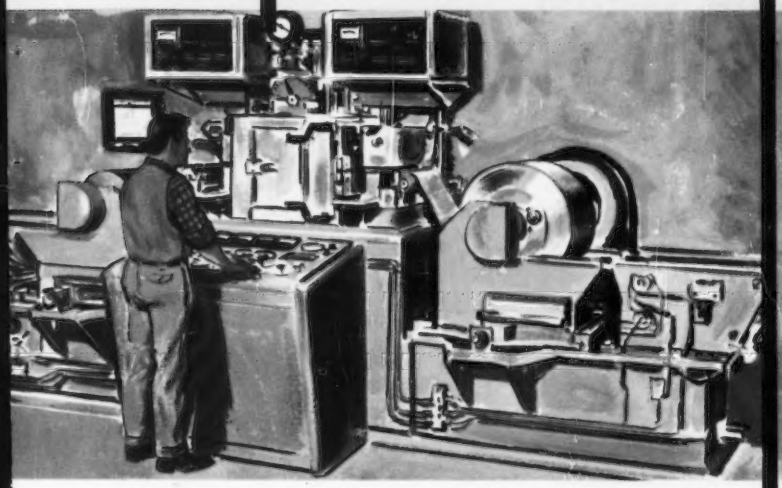

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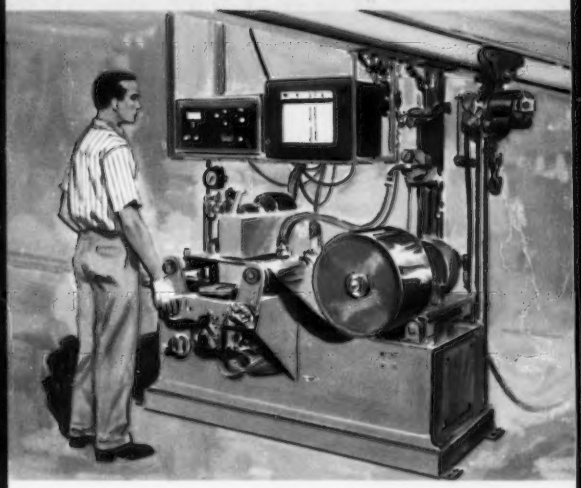

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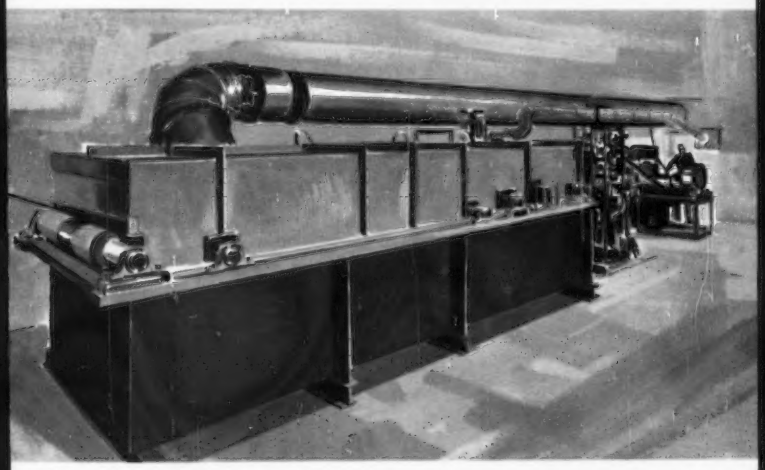

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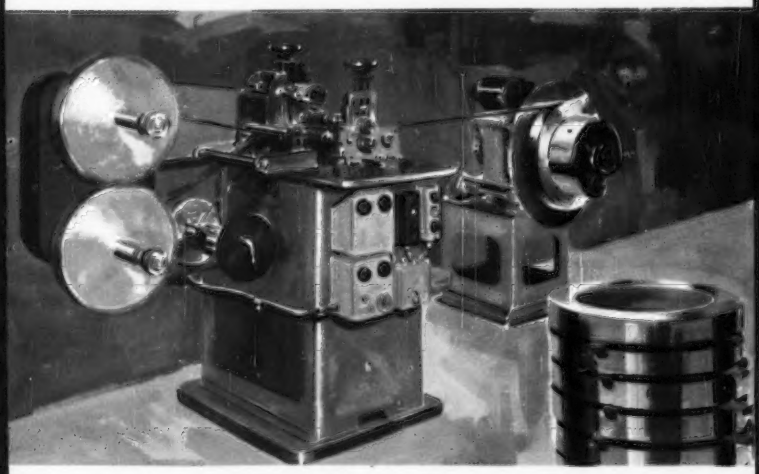

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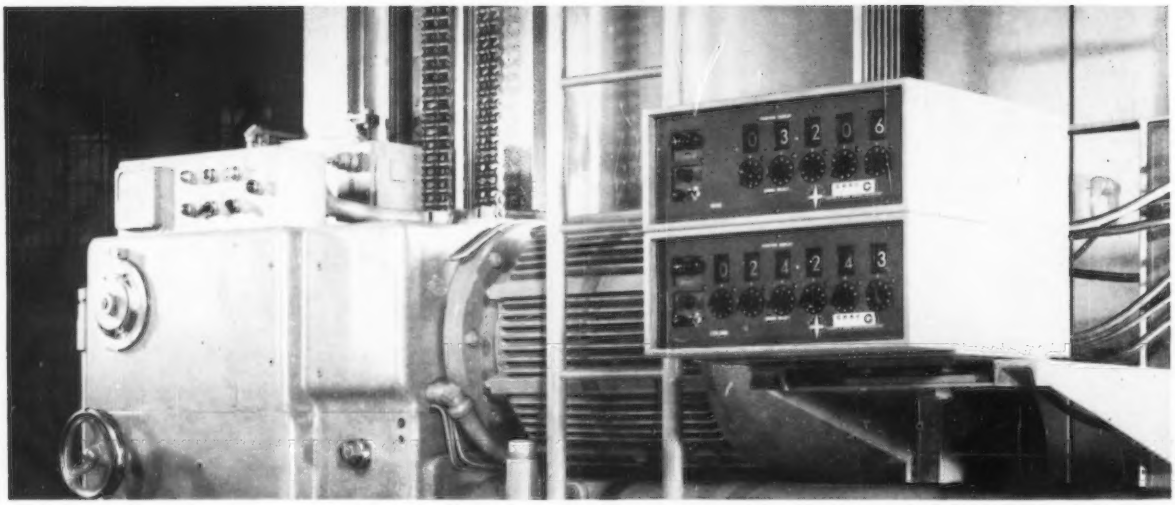

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What We Need To Win Aerospace Race With Russia

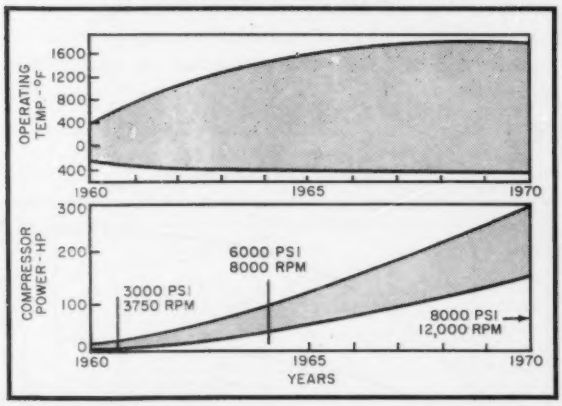
Seventh forecast of Aerospace Industries Association projects technological requirements for next decade; Report based on consensus of key experts in industry

Five Technical Committees of the Aerospace Industries Association (AIA) have published a cooperative report on future trends and needs in aerospace technology. The report reflects the combined opinion of over 200 research and engineering experts. It is published as an advisory to U. S. Governmental and defense agencies, and to industries serving the aerospace manufacturer.

The following is a summary of the Aerospace Forecast of Technical Requirements compiled by the AIA.

Trends In Electronic Equipment—Use of micro-miniature parts and molecular electronics will increase in equipment where (1) weight and size are of primary importance, (2) requirements for precision toler-

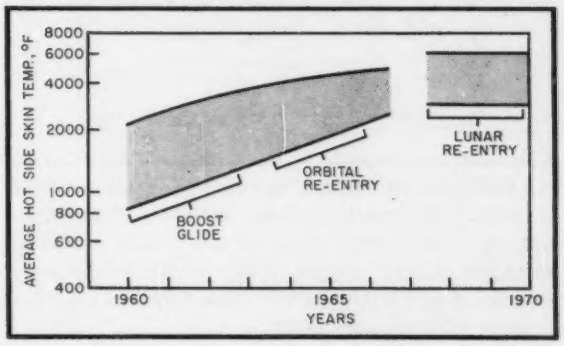
HIGH-PRESSURE PNEUMATIC SYSTEMS



HORSEPOWER for pneumatic system compressors may climb to 300 by end of decade. System operating temperature still climbing.

OPERATING TEMPERATURES will increase greatly as vehicles evolve from boost glide to orbital re-entry to lunar re-entry systems.

TEMPERATURE TRENDS FOR MANNED RE-ENTRY VEHICLES



The 1000 to 10,000 mc range appears best for piercing ionosphere and minimizing atmospheric attenuation

ances have been somewhat lessened, and (3) heat-generating parts can operate at low-power level.

Greatest need for intensified research in this area centers on new materials, both natural and synthetic, studies on purity, crystalline structure, and basic properties.

Current airborne electronics has a maximum parts density of about 30,000 parts per ft³. Welded module construction will increase the maximum density by about 60 per cent and will represent the best efforts with conventional components. True microminiaturization begins with vacuum deposited resistors, conductors, and capacitors with microsized transistors as the active elements. Serious production of this ½ million-part-per-ft³ will begin in 1961. Semi-conductor (molecular electronics) circuitry with another magnitude of parts density will follow closely. Micro-miniaturization will grow from the modest proportions of 1960 to large scale industry operations within the next ten years.

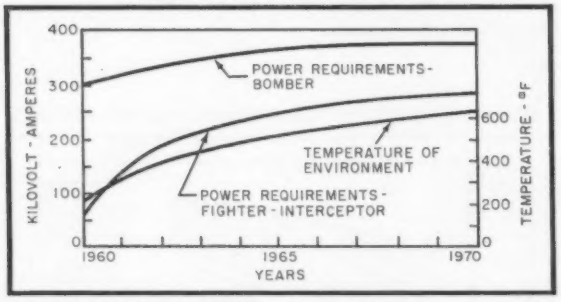
A significant departure from "Component Orientation" to "Function Orientation" will occur when molecular electronics enters the commercial picture.

During the 60's, a much higher activity in the 1000 to 10,000 mc range is anticipated. This range appears best for piercing the ionosphere and for minimizing atmospheric attenuation. The trend to the higher frequencies is accelerated by the need for higher data rates in telemetry and data link. The increased bandwidths afforded in the 1 to 10 kilo-megacycle range greatly increase the rate at which data can be transmitted over a given channel. Requirements for new and better transmitters, receivers, data handling devices and antennas for operation at microwave frequencies will steadily increase during the next decade. The crowded radio frequency spectrum and the rising importance of secure and private wireless communication will bring about increased attention to (1) transmission at very low frequencies (below 30 KC), (2) use of the earth as a communication system, (3) modulation of waves in the visual and infrared ranges, and (4) use of scatter of "bounce" techniques from natural or artificial reflectors (e.g., satellite "mirrors").

Plastics—Future plastic design especially related to space and upper atmosphere vehicles may require consideration of environments other than temperature as having primary significance. These environments are: electromagnetic and particle radiation, induced mechanical and acoustical vibrations, thermal and mechanical shock, cyclic temperature differentials, vacuum, and ozone degradation.

Low Temperature Metals—Increasing use of liquid oxygen-liquid hydrogen propellants in space vehicles indicates that high-strength structural alloys possessing useful engineering properties to –423°F will be required during the period 1960-70. These alloys must have high strength/density ratios accompanied by good toughness (i.e., resistance to brittle failure) at cryogenic temperatures as measured by notched/unnotched tensile ratios, or tear tests. In addition, these alloys must be weldable, and the weld joint must also exhibit good toughness at low temperature. The extreme sub-zero temperature requirements mean that only those materials which do not exhibit ductile-brittle transition behavior can be considered for this type of application. Examples would include the cold-rolled austenitic stainless steels

ELECTRICAL SYSTEMS TRENDS



ALTERNATOR SPEED will vary from present 8000 rpm to 12,000 continuous duty and 24,000 intermittent duty by 1965. System frequency will remain at 400 cps for most manned vehicles of this period. Missiles and unmanned space vehicles will show increasing applications of 3200 cps after 1963.

REMOVAL OF HEAT resulting from higher speed atmospheric flight and from higher-energy, steeper reentries will call for greater reliance on refrigeration systems.

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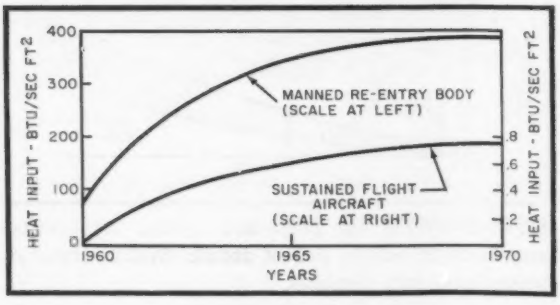
ESTIMATES OF HEAT INPUTS



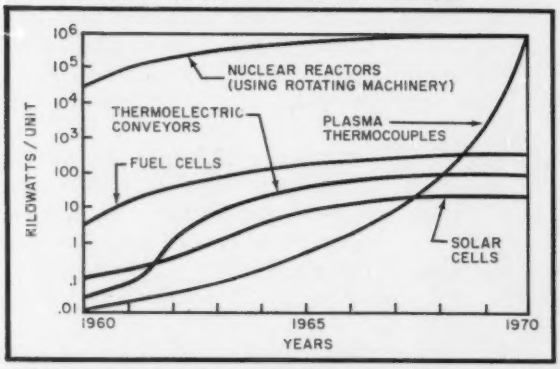
(e.g., AISI type 301 and 310), certain aluminum alloys such as 2014-T6, 5052-H39, and 5456-H38, and the alpha titanium alloys such as AllOAT, with specific selection depending on design factors such as tensile stress or elastic stability (e.g. buckling) limitations.

Development activity in the next ten years should be focused on the alpha titanium alloys, which have outstanding strength/density characteristics at cryogenic temperatures. In addition to AllOAT (5Al-2.5Sn) now in production, newer alloys such as 5Al-5Zr-5Sn, 8Al-1Mo-1V, and 8Al-2 Cb-1Ta should be thoroughly evaluated in both the base metal and welded joint configuration. Development activity in aluminum base alloys should be directed toward high purity alloys such as 7275, which can be produced by techniques such as controlled atmosphere melting, and ultrasonic treatment during ingot solidification. Development activity in the austenitic stainless steels should be directed toward studying effects of vacuum melting, and stress relief heat treatments.

Other development activity in this area should be directed toward determining the useful temperature limits of certain promising alloys. For example, the 6Al-4V titanium alloy has been used successfully at –320°F, but appears to be seriously embrittled at –423°F especially in welded joint. The heat treatable stainless steels such as AM350, AM355, A286 have shown promise at –320°F, but display decreasing toughness at –423°F, although heat treatments intended to condition these alloys for service at –423°F show promise. Other alloys may also be found to possess useful properties for specific applications at moderately low temperature as a result of special heat treatment or other special processing.

Coatings And Finishes—Higher temperature coating requirements are presently met by ceramic materials, such as oxides, carbides and silicides, applied by plasmajet and

UTILIZATION OF NEW ENERGY SOURCES



POWER CAPACITY ESTIMATES of new energy sources are given above; required output must await definition of specific application characteristics.

RELATIVE DEVELOPMENT ACTIVITY is illustrated as expected to occur in broad categories of the radio frequency spectrum, as related to communications equipment. Anticipated increase in expenditures in communications may shift the emphasis in some categories.

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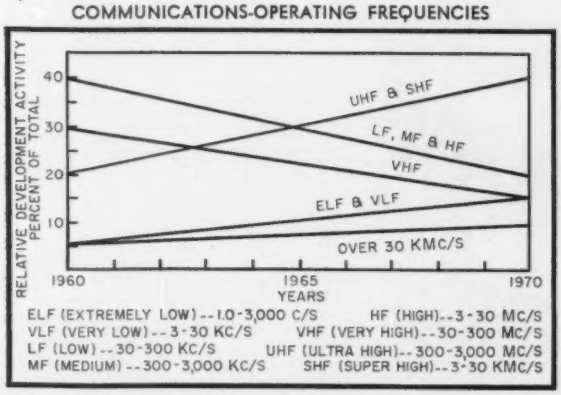
COMMUNICATIONS-OPERATING FREQUENCIES



HUMAN MONITORING of vehicle performance data will be limited to simple audio and/or visual indications of compliance or non-compliance, with a choice for alternative courses of control action. The trend towards integrated-type indicator displays will continue.

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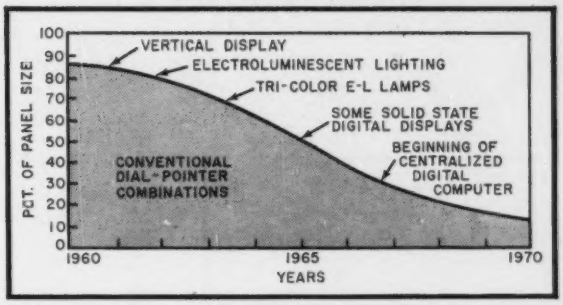
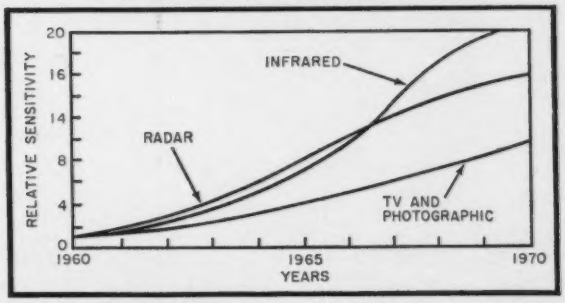
COCKPIT DISPLAY SYSTEMS



SURVEILLANCE AND TRACKING SENSITIVITY



GROWTH TREND of surveillance and tracking technique is presented, based on the anticipated reduction to practice of current advanced concepts. Systems are required to detect and plot submarine traffic over entire ocean basins. A technological breakthrough in high altitude submarine detection is urgently needed.

Fluorocarbon rubbers still offer best immediate answer to high temperature, high physical property, and fuel resistance

flame spraying. Typical applications include rocket nozzle linings and rotating shafts. The trend is toward protection against very high temperatures for relatively short periods of time, e.g. one operating cycle. Tailored coatings for specialized applications will become of increasing importance, with self-healing characteristics required in some cases. Rapid heating requirements will result in emphasis on more ductile coatings and on matching of coefficients of expansion. Special high - temperature materials, such as organics for protection of ablation, will be improved.

Intermediate temperature coating requirements are currently met by thin metallic coatings applied by electro-and electroless-plating, dipping, spraying, vacuum deposition and arc deposition. These coatings are used to provide oxidation and corrosion protection, wear resistance, altered emissivity properties, diffusion barriers, etc. Metallic coatings, with their inherent ductility, are generally more durable than ceramic coatings. The trend is toward increased usage of metallic coatings for specialized applications, and precious metal coatings and multilayer coatings to achieve a combination of properties in one coating. Coatings will be developed for use at liquid-gas low temperatures as well as for use at higher temperatures.

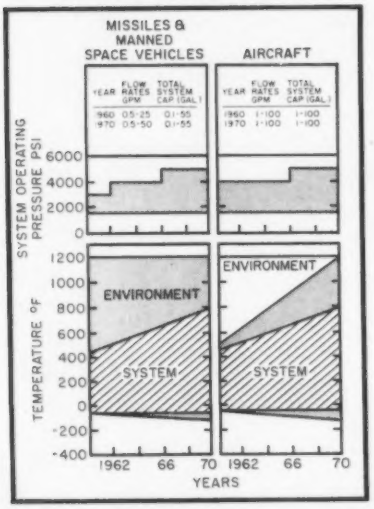
Elastomer Consumption—New experimental highly saturated olefins possess good heat resistance and could replace natural rubber when more data on radiation effects have been determined.

Neoprene consumption has already been reduced by other elastomers in application requiring better ozone resistance, low temperature flexibility or fuel resistance. Fluorosilicone, Acrylic, and butadiene/Acrylonitrile/Polyvinyl chloride terpolymers are making inroads.

Butadiene/Acrylonitrile polymers still remain the single most important elastomer for fluid seals and hose liners. However, inadequate ozone, low and high temperature resistance of the polymer will reduce its importance as more stable polymers appear. The fluorocarbon rubbers are now and will continue to replace B/A polymers.

Use of Polysulfide rubber is declining. As a solid propellant binder/fuel, it is being challenged by polyurethane, polybutadiene, carboxynitrile and other polymers. Use as a tank and cabin pressure sealant remains high because no other material has been able to match its proven qualities and offer in addition the higher temperature resistance needed.

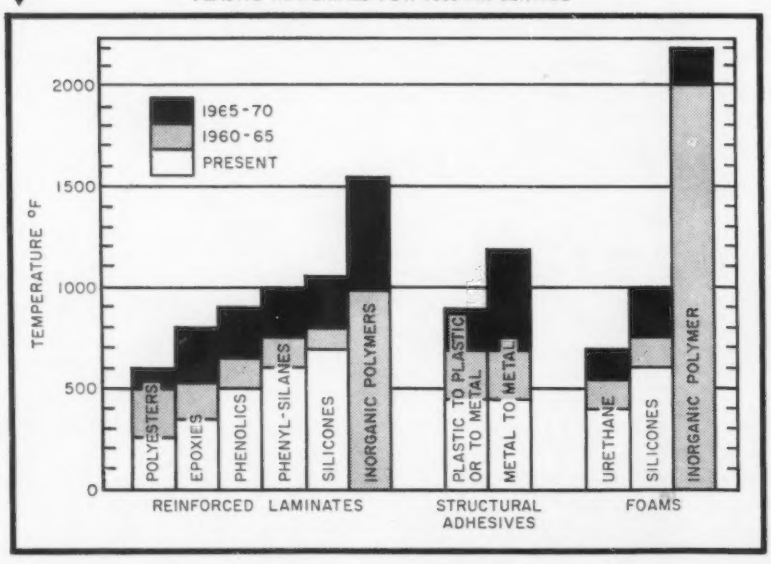
HYDRAULIC-SYSTEM TRENDS



FLOW RATES shown are maximum anticipated short-time demands. Aircraft environmental and system temperatures correspond to highest performance vehicles only, and exceed those anticipated for transport-type aircraft.

FUTURE REQUIREMENTS for structural plastic materials are drawn, based on present capabilities. Inorganic polymers (foam and reinforced) promise superior heat-resistant qualities and offer a desirable area for R&D.

PLASTIC MATERIALS FOR 1000-HR SERVICE



Silicone use will continue to increase, particularly the fluorosilicones. A high strength version of presently available fluorosilicone compounds would be welcome and would replace Butadiene/Acrylonitrile rubber in high temperature seal and hose problem areas.

The progress of solid polyurethanes has not been rapid. High temperature limitations coupled with non-conventional manufacturing techniques has retarded their growth. However, the unlimited variety of polymers that can be made and improved processing techniques will bring about increased usage. Use as a binder/fuel in solid propellants may increase as physical and ballistic characteristics are improved.

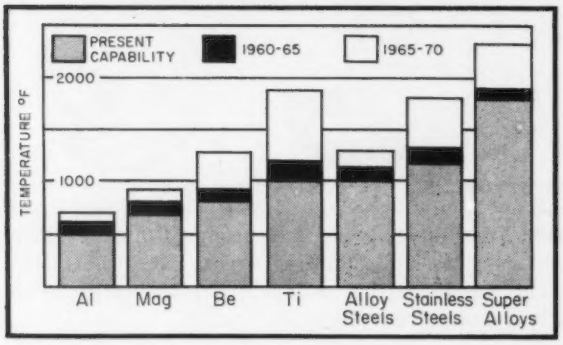
Butyl rubber consumption increases, as a result of its effectiveness as an inert polymer for fabricating seals and hoses for use with phosphate ester hydraulic fluids, hydrazine, unsymmetrical dimethyl hydrazine, and other extremely reactive liquid propellant fluids. Other new olefins still in the development stage could reduce its importance.

Fluorocarbon rubbers are still the best immediate answer for high temperature, high physical property, and fuel resistance. Fluorosilicones are the most valuable materials where both extremely low temperature and high temperature conditions and fuel and hydraulic fluid resistance is necessary. Nitrile or Cyano silicones have been disappointing. However, this elastomer type formulated into compounds with physical properties and fluid resistance equal to the present Nitrile seal and hose compounds would be welcome.

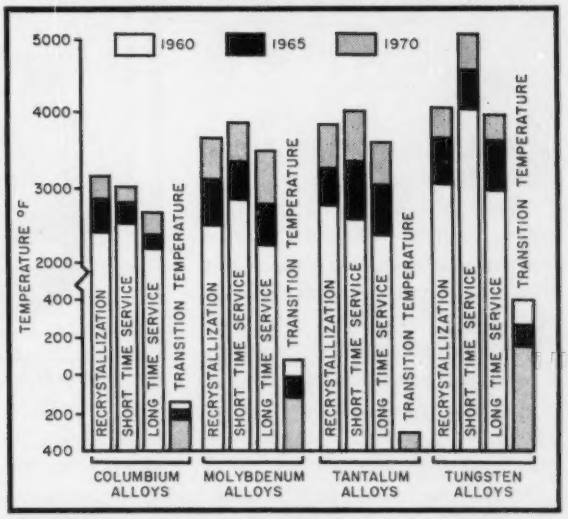
The most promising experimental new elastomers are the olefins, completely saturated or with low unsaturation. These lack fuel resistance but have heat stability up to 400°F. They could be a low cost

LOWER DENSITY MATERIALS having a useful life at higher temperatures are needed for structural applications. ▼

THERMAL CAPABILITIES OF METALS

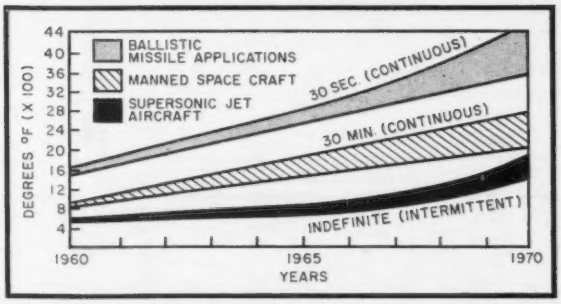


PROJECTED IMPROVEMENTS OF REFRACTORY METALS



PROPERTY IMPROVEMENTS considered feasible are indicated for the alloys of the four most-available refractory metals. Oxidation preventive coatings should be developed to take advantage of the full useful strength ranges of refractory alloys.

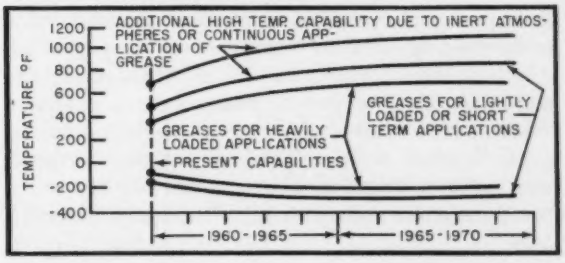
ELASTOMER APPLICATIONS



HIGHER TEMPERATURE and shorter exposure trends continue in elastomer applications. For high temperature environments elastomers may have physical attributes of rigid thermoplastics at ambient. Crosslinked polyethylene is an example of such a material.

TEMPERATURE RANGES given at a specific date refer to the general capabilities of grease lubrication and not to a single grease.

▼ RANGE OF GREASE LUBRICATION



Space-vehicle-environment simulation will account for bulk of facility-development activity in 1960 to 1970 period

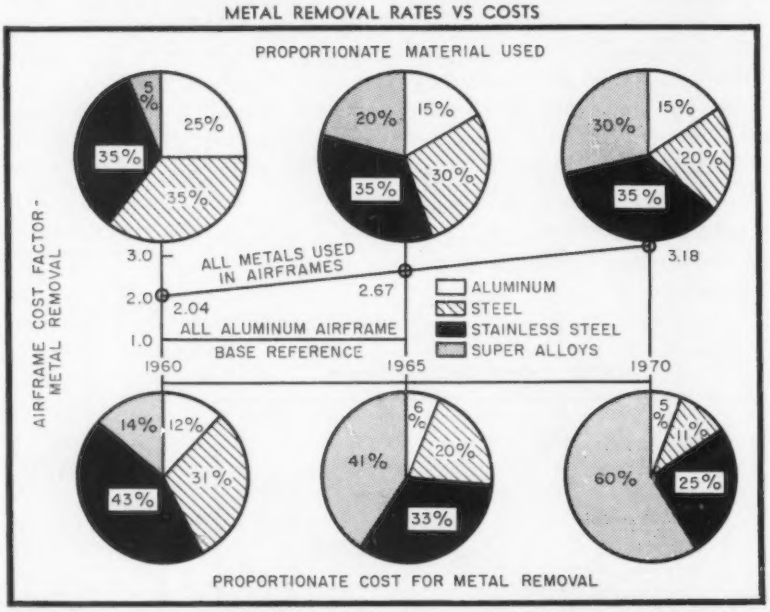
replacement for silicones in nonfluid applications. They are chemically inert, but can be cross linked by radiation or other known techniques.

Hydraulic Systems — The fluid operative range required of hydraulic fluids is expected to increase from –65 to 450°F in 1960 to –50 to 850°F by 1970. Since it appears probable that no one fluid which is serviceable over the entire range will be available, no single system is likely to operate over the entire range. Other requirements for fluids are: (1) Compatibility with serviceable non-metallic and metallic materials at operating temperatures; (2) Sufficient lubricity at operating temperatures; (3) Fire resistance or a minimum fire hazard at operating temperatures.

Most presently used materials appear to have sufficient radiation resistance until nuclear powerplants come into use. Present systems cleanliness requirements vary widely. Cleanliness of some systems is checked by visual examination of coarse filter paper after sample filtration. At the other extreme, systems containing low power, critical tolerance values must be free of particles in the 2 to 5 micron range to achieve sufficient reliability. As system temperatures increase, the challenge will be to maintain present levels of system cleanliness.

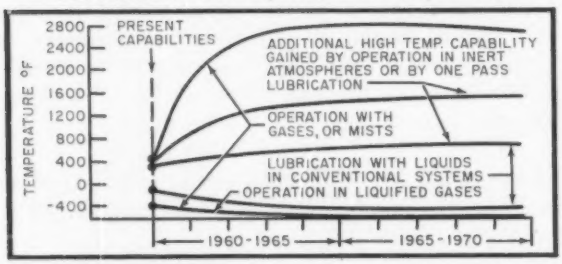
Experimental Facilities—Space-vehicle-environment simulation will account for the bulk of facility development activity in the 1960-1970 period. Space regime variables are unique with relatively unknown ef-

METAL REMOVAL RATES VS COSTS



RISING METAL-REMOVAL COSTS are accompanying the shift from aluminum to high-strength thermal-resistant materials. Top "pie chart" series shows the increased use of common airframe materials; bottom series shows resulting changes in cost of metal removal.

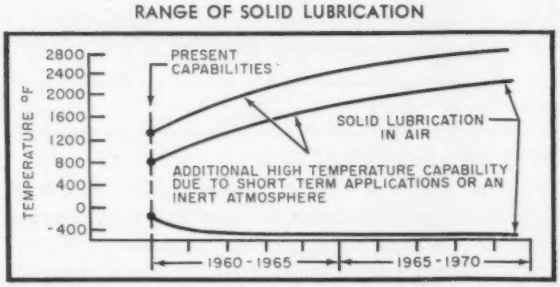
LUBRICATION WITH LIQUIDS, GASES AND MISTS



REACTIVE GASES such as Freon may be used which decompose and continuously form a lubricating film on the bearing metal or bearings may use a gas film under pressure to support the load. Mists of organic liquids are used to protect bearings from oxidative attack at high temperatures and to supply lubricating agents to metal surfaces. Operations at low temperatures can be provided by gas supported bearings or by the operation of rolling element bearings in liquefied gases.

BONDED SOLID FILMS, lubricating coatings formed by reactions with the base metal and lubrication with powdered solids such as graphite and lead oxide are considered in this chart.

RANGE OF SOLID LUBRICATION



fects, and vehicle launch, boost, re-entry and recovery phases induce higher energy levels of vibration, acceleration, shock and aerodynamic heating when traversing through atmospheric regimes.

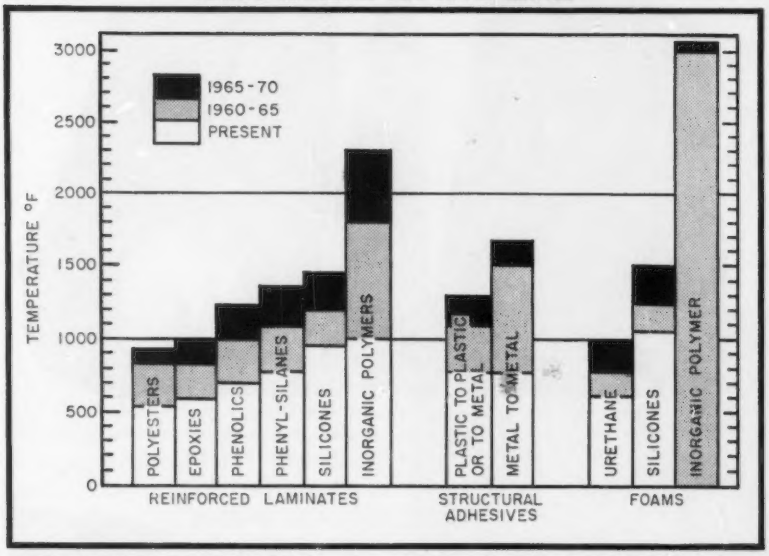
System operating media for new vehicle types require development of specialized generating, storage, distribution and control equipment to provide media for operation of systems or components during test.

- Cryogenic facilities to supply liquefied gases or high-energy fuels at extreme low temperature (–320° to –450°F).
- High pressure pneumatic facilities (3000-10,000 psi) for air, nitrogen, helium and other gases.
- High temperature hydraulic facilities (275°-1000°F).
- High velocity, high temperature gas flow facilities at relatively low pressure.
- High capacity specialized A. C. and D.C. power sources.

Environment Simulation—Combination of environmental variables in the past decade has been largely limited to the category of interdependent variables (e.g., temperature - humidity, temperature - altitude), and to an increasing extent, combination of vibration with several of the natural variables: temperature, altitude, humidity. Missiles and space vehicles encounter increased levels of induced environment from propulsion media and transitional regimes, and the ultimate regime of space presents new variables of natural environment which are highly interdependent. Thus, the trend toward simulation of combined environment will be primarily in conjunction with space vehicle developments.

✦

PLASTIC MATERIALS FOR 0.1-HR SERVICE



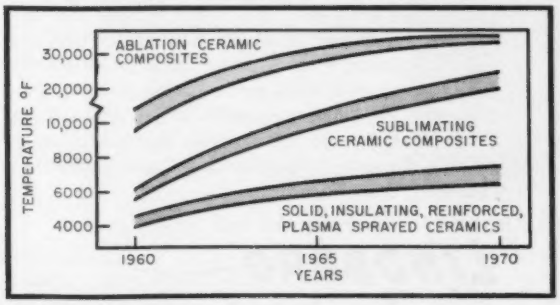
SHORT-TIME EXPOSURE requirements for plastics are primarily related to rocket missile and re-entry vehicles. Ablation applications are mainly a matter of specialized selection of design and materials and are not considered here.

A REPRINT
of this article can be obtained by writing on company letterhead to The Editor, AIRCRAFT & MISSILES, Chestnut & 56th Sts., Phila. 39, Pa.

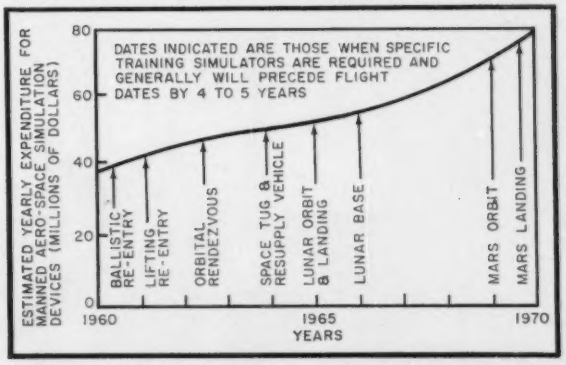
COMPOSITE SYSTEMS are now utilizing ablation, plasma-sprayed, and metal-reinforced ceramic coatings. Developments are needed to take advantage of high-melting-point materials as either protective systems or materials of construction.

▼

TEMPERATURE LIMITATIONS OF CERAMIC MATERIALS



SIMULATION FACILITIES FOR MAN-VEHICLE EVALUATION



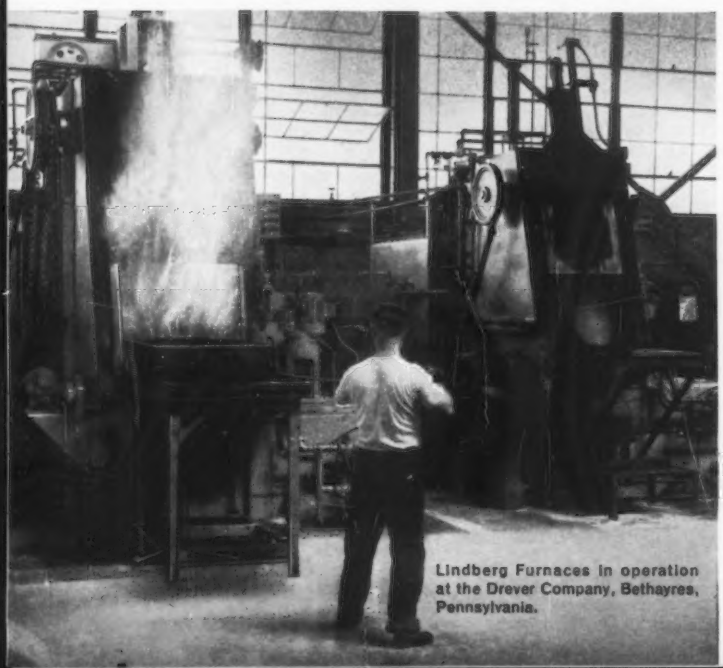
ANNUAL EXPENDITURE of about $40 million for current aerospace simulation devices may double over the next ten years. Increasing complexity of manned aerospace vehicles stresses the need for high-fidelity simulators to study man's ability to control and navigate these vehicles under the combined stresses of hyper-environments.

What HORACE DREVER has to say about Lindberg heat treating equipment

Mr. Horace Drever, internationally prominent in the industrial heating field, is a Past-President of the Furnace Manufacturers Association and President of Drever Company, furnace manufacturers and commercial heat treaters.

QUOTE from Mr. Drever's unsolicited letter to Lindberg Engineering Company

"For the past three and one-half years, we have been operating one of your Type 243618 GVRT Furnaces along with a 500 CFH Lindberg Hyen generator in our commercial heat treating division. We are extremely pleased, not only with the fine quality of work turned out by this equipment but also its relatively trouble-free operation. As evidence of our complete satisfaction we have ordered another Lindberg Furnace of this type."



Lindberg Furnaces in operation at the Drever Company, Bethayres, Pennsylvania.

We are happy that Mr. Drever, a furnace manufacturer in his own right, originally chose Lindberg equipment for his heat treating plant and that its satisfactory service prompted an additional order. The second Lindberg Furnace is now in production at Drever Company, as the adjacent photo shows. Bless those satisfied customers! If you have a product or process in the metal or ceramic field requiring the application of heat you can depend on Lindberg's engineering and design know-how to provide exactly the right equipment to answer your need. Get in touch with your nearest Lindberg Field Representative (see classified phone book) or write direct to Lindberg Engineering Company, 2473 West Hubbard Street, Chicago 12, Illinois. Los Angeles plant: 11937 South Regentview Avenue, Downey, California. In Canada: Birlefco-Lindberg, Ltd., Toronto.

LINDBERG
heat for industry

NASA's Goals For Next Decade

Projected expenditure rate over $1.5 billion per year; Standardization guides design of boosters and spacecraft; Man's immediate role confined to near-Earth orbital flights

By S. Peter Kaprielyan

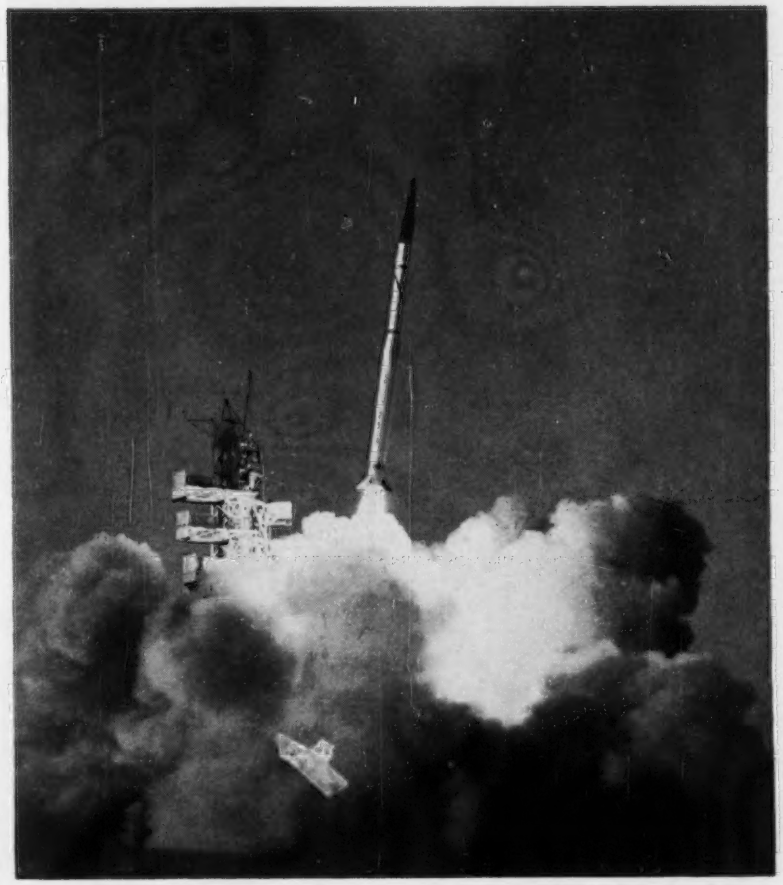
The National Aeronautics and Space Act of 1958 defines the long-range objectives for NASA as: "the preservation of the role of the United States as a leader in aeronautical and space science and technology and in the application thereof to the conduct of peaceful activities within and outside the atmosphere."

Behind this terse "Declaration of Policy and Purpose" are now unfolding assuredly the most ambitious plans conceived by man—ahead of it lies an expanse to challenge the imagination of generations to come.

A year ago this month, NASA presented to the Congress its first Ten-Year Plan to fulfill its missions. In the light of gained experience, annual revisions are now intended to reappraise our space mission on a continual basis.

NASA's extensive program calls for the initially-unmanned exploration of the moon and planets. The broad scientific objectives, involving nearly all of the scientific disciplines, is to gather data on the following:

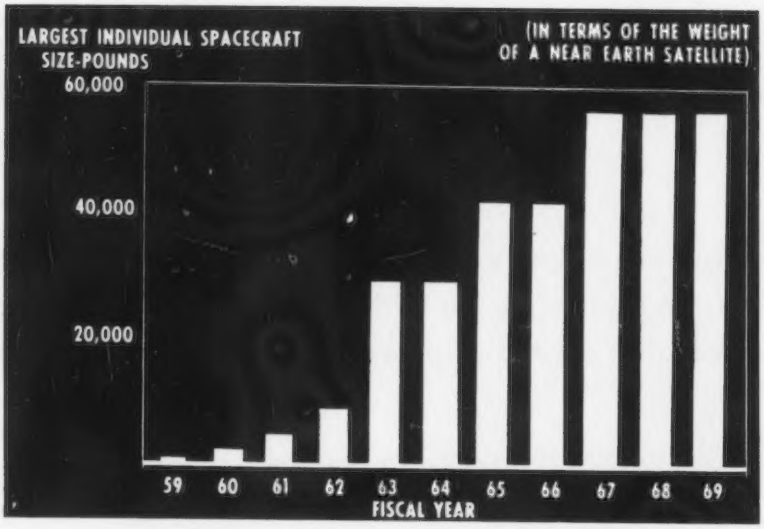
- Physics of the moon and planets
- Solar and interplanetary physics
- Biosciences and extraterrestrial life
- Cosmology — the effort to



ALL-SOLID SCOUT is four-stage, economy vehicle launched from NASA's Wallops Island, Va., facility. Chance Vought's Astronautics Div. is project manager.

←——Circle 15 on Inquiry Card

Multi-purpose Scout vehicle can place up to 150 lb into 300-mi orbit



ANTICIPATED GROWTH OF NASA SPACECRAFT SIZE

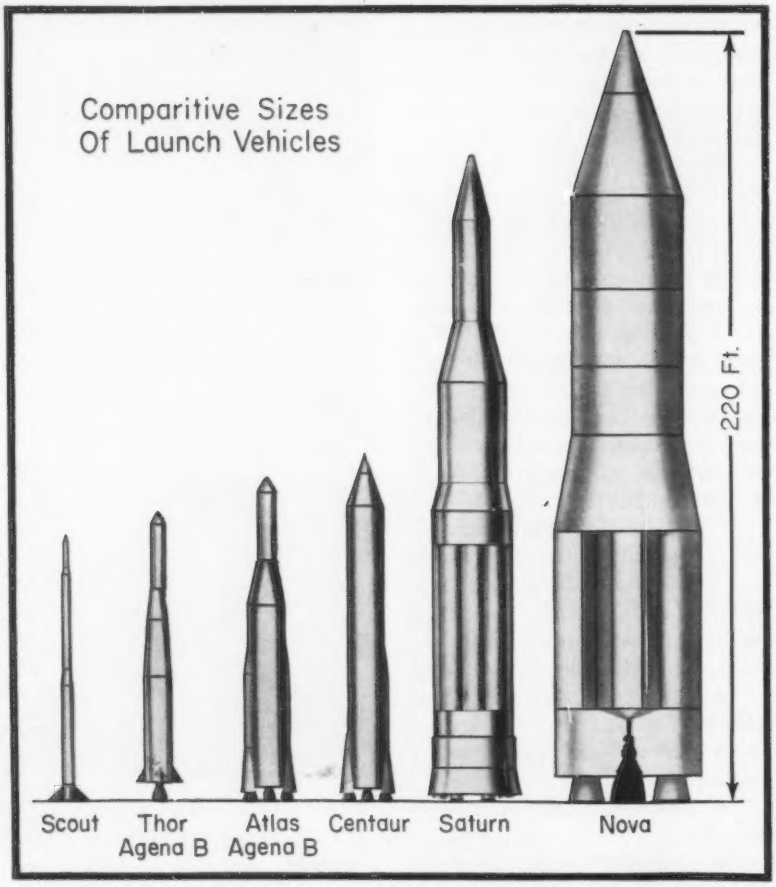
piece together the biggest of all puzzles, for a better understanding of the nature and origin of the solar system, and ultimately of the universe itself.

In the course of carrying out this program, the following technologies will be developed:

- Navigation, guidance and control
- Long-range communication
- Entry into planetary atmospheres
- Remote landings on moon and planets
- Surface transportation techniques in strange environments
- Utilization of natural resources yet to be found

Approximate number of launchings anticipated for next decade include: 62 for the development of launch vehicles, 41 for missions relating to manned space-flight, 96 for scientific satellites, 33 for lunar and planetary scientific missions,

RANGER SPACECRAFT series includes seven experiments approved for flight. Spacecraft is being developed at Jet Propulsion Lab., capsule at Aeronutronic Div., Ford Motor Co.



and 28 for satellite application such as communications. The total number of these corresponds to a rate over two major missions per month.

The year 1960 marked the first transition of our space effort. By necessity, early launch vehicles used by NASA were based on the Vanguard program and the guided missile programs of the DOD. Increasing use of the versatile Scout now marks the advent of vehicles planned specifically for space missions.

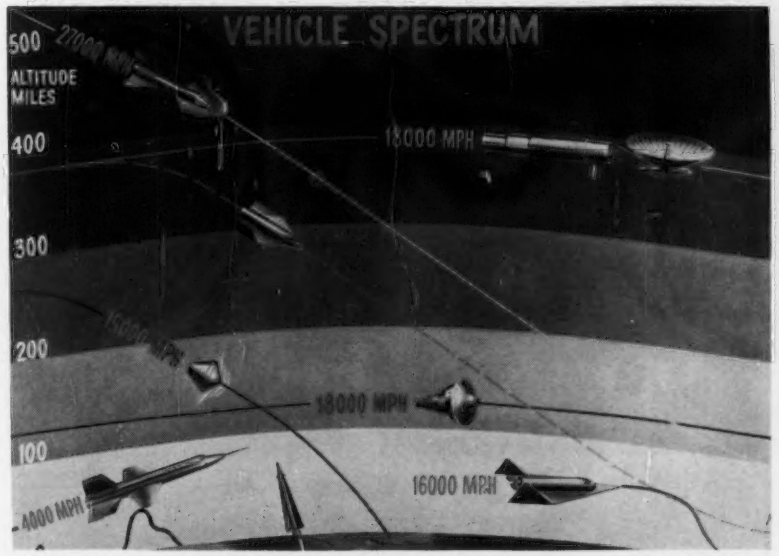
NASA's current basic vehicle program contains six types: Scout, Thor-Agena B, Atlas, Atlas-Agena B, Centaur, and Saturn. Of these, the Thor-Agena B's and the Atlas are also due to be phased out.

Only eight Thor-Agena B's are programmed for NASA missions of the near future. Atlas, with its low-orbit-altitude capabilities, will remain active for Project Mercury's early missions; more powerful boosters will take over later.

Scout—This is a multi-purpose, four-stage solid-propellant, economy vehicle with up to 150 lb for 300 mi orbit missions. Other uses for Scout include the lifting of a useful payload up to 4000 mi, atmospheric testing of high-speed airframe designs, and re-entry studies. It will be launchable from the Atlantic and Pacific Missile Ranges, as well as from Wallops Island, Va. Scout's production versions plus launching operations may cost about $1 million.

Thor - Agena B — A Thor (IRBM) first stage and an Agena B second stage (enlarged version of Air Force's Discoverer) make up this vehicle. Missions will include scientific satellites, meteorological satellites, and others requiring medium-weight payloads. Launchings are to be from Pacific Missile Range, into polar or highly inclined orbits.

Atlas-Agena B—This is the upper stage of Thor-Agena B wed to



SPEEDS AND CONFIGURATIONS are given for some representative re-entry vehicles.

JPL SURVEYOR PROJECT
SCIENTIFIC EXPERIMENTS PLAN

Experiment	Instrument and Measurements
Surface Chemical Analysis	1. X-ray fluorescence spectrometer 2. Neutron activation techniques 3. Mass spectrometer 4. Gas chromatography (Detection of organic molecules)
Surface Physical Analysis	1. Densitometer (γ-ray scattering) 2. Thermal and electrical conductivity measurements 3. Sound speed measurements 4. Vidicon with variety of magnifications
Local Sub-Surface Properties (Drill to 4 or 5 feet)	1. X-ray spectrometer and neutron activation instrument in cavehole 2. Vertical temperature gradient measurement 3. Thermal and electrical conductivity measurements 4. Densitometer
Structure	1. Three-axis seismometer 2. Gravimeter

JPL RANGER PROJECT
MISSION OBJECTIVE PLAN

Spacecraft	Objective
RA-1	A. Engineering tests of 1. Attitude control system 2. Solar and battery power supplies 3. Communication equipment 4. Lifetime of components in space environment B. Scientific studies of interplanetary medium 1. Fields and charged particles 2. Hydrogen 3. Dust C. High elliptical orbit, near escape energy
RA-2	Same as above; lunar fly-by if possible
RA-3 RA-4 RA-5	A. Engineering tests of 1. Landing survivable package on moon 2. Midcourse guidance technique B. Scientific studies of lunar environment and surface Capsule: Seismology Bus: γ-ray spectroscopy and photography of small lunar area

JPL RANGER PROJECT SCIENTIFIC EXPERIMENTS PLAN

Spacecraft	Experiment	Instruments and Measurements	Cognizant Agency and Scientist
RA-1 RA-2	Fields, charged particles, and solar X-rays	1. Electrostatic analyzer for solar plasma 2. Semiconductor detectors and thin-walled geiger counter A. CdS photoconductor B. Thin-walled geiger C. Medium-walled geiger D. Au-Si counter	JPL M. Neugebauer, C. Snyder St. U. of Iowa/U. of Chicago J. A. Van Allen/J. A. Simpson
		3. Ionization chamber	Caltech/JPL H. V. Neher/H. R. Anderson
		4. Triple-coincidence telescopes	U. of Chicago J. A. Simpson
		5. Rubidium vapor magnetometer	Goddard Space Flight Center J. P. Heppner
		6. X-ray scintillation detectors	LASL/Sandia Corp. J. A. Northrop
	Hydrogen geocorona	1. Lyman alpha telescope	Naval Research Lab/JPL T. A. Chubb
	Interplanetary dust	1. Micrometeorite composite detectors	Goddard Space Flight Center W. M. Alexander
RA-3 RA-4 RA-5	Capsule: Seismology	1. Seismometer	Caltech/Columbia Univ. F. Press/M. Ewing
		2. Capsule temperature measurement	
	Bus: Photography of Small lunar area and γ-ray spectroscopy	1. Vidicon television	JPL E. F. Dobies
		2. Gamma ray spectrometer	Univ. of Calif./LASL/JPL J. R. Arnold/M. A. Van Dilla E. C. Anderson/A. Metzger

Nova would orbit 290,000-lb space-lab at 300 mi or carry 100,000 lb to the moon

an Atlas first stage. Joint use of this vehicle by Air Force and NASA calls for numerous launchings leading to high reliability. It is principally for early lunar exploration and scientific Earth satellite uses, and may eventually be replaced by Centaur. NASA plans launching most Atlas-Agena B vehicles from Atlantic Missile Range, and a few from the Pacific Missile Range.

Centaur — An Atlas first-stage with a hydrogen-oxygen-propelled second-stage give this vehicle the greatest capability of Atlas-boosted series. Centaur is now in an advanced stage of development. Though slated for military programs, Centaur will also be used in many scientific missions such as lunar and planetary exploration and geophysical satellites. It will be launched from Atlantic Missile Range.

Saturn—This first heavyweight of the projected "workhorse" vehicles will make its presence felt about the middle of the next decade. For a detailed description of the Saturn, refer to page 17.

Nova—Beyond the Saturn looms the colossal concept of the 4.5-million-lb Nova composed of five stages. Nova would be capable of orbiting a 290,000-lb space lab at 300 mi or carry 100,000 lb to the moon. Only portion of Nova currently under development is the 1.5-million-lb-thrust F-1 engine. First two stages of Nova might be composed of clusters of F-1 engines. Nova concept is described on page 62.

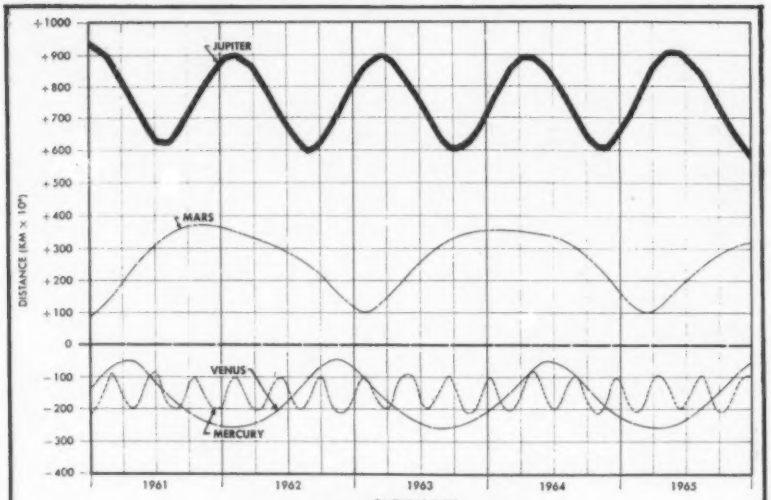
The basic types of launch vehicles described above will perform a wide variety of missions as outlined for the next decade.

Major Goals in NASA's Ten-Year Plan

1961—First orbital flight of an astronaut — First launching of a lunar impact vehicle—Launching of a deep-space probe using Thor-Delta vehicle—First launching of Centaur vehicle—First launching of Ranger spacecraft using Atlas-Agena B.

1962—First launching of instrumented-probe Mariner to vicinity of Venus and/or Mars, using Centaur —Launching of second series of lunar-impact probes using Atlas-Agena B—First launching of a two-stage Saturn.

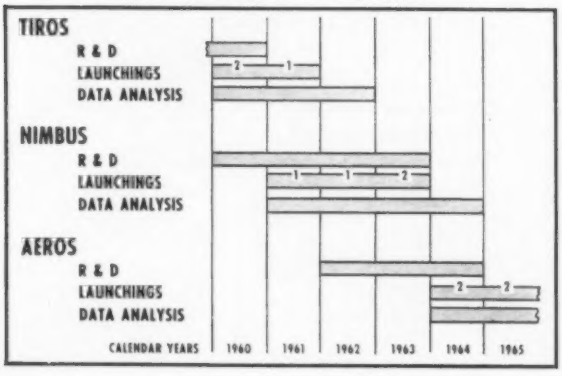
RELATIVE PLANET DISTANCES AND PERIODS



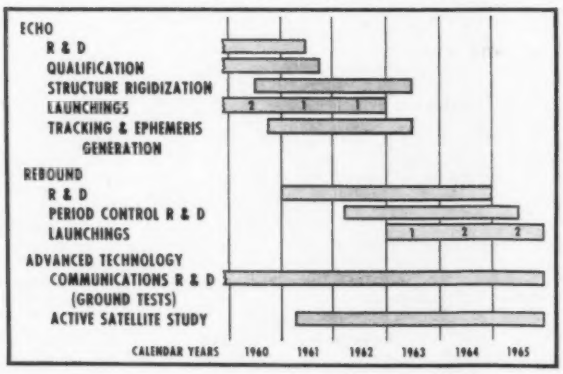
LAUNCHING OPPORTUNITIES

1960 —	—	MARS	1966 —	—	MARS
1961 —	VENUS	—	1967 —	VENUS	—
1962 —	VENUS	MARS	1968 —	—	MARS
1963 —	—	—	1969 —	VENUS	—
1964 —	VENUS	MARS	1970 —	VENUS	—
1965 —	VENUS	—			

METEOROLOGICAL SATELLITE PROGRAM



COMMUNICATION SATELLITE PROGRAM



1963-64 — First launching, by Centaur, of unmanned-vehicle Surveyor for soft landing of 100 to 300-lb instrumented payload on moon—First launching of an orbiting astronomical observatory.

1964—First launching of an unmanned vehicle intended to circumnavigate the moon and return to Earth — First reconnaissance of Mars and/or Venus by an unmanned vehicle.

1965—First flight-test of a nuclear second-stage — Spacecraft Prospector to soft-land a mobile vehicle on moon, using Saturn—Spacecraft Voyager, using Saturn vehicle, to orbit Mars and Venus and eject instrumented capsule to relay environmental data via orbiting mother craft, or possibly, directly to Earth.

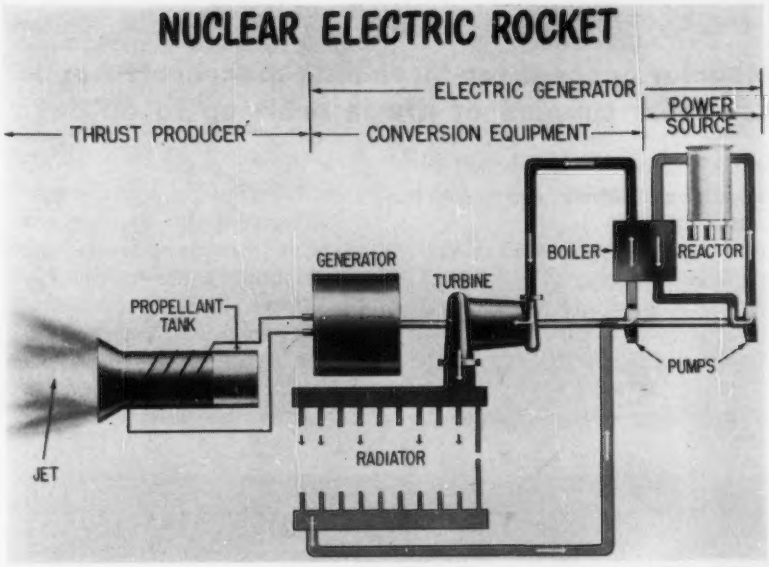
1965-67—First launching in a program leading to manned circumlunar flight, and to a near-Earth space station.

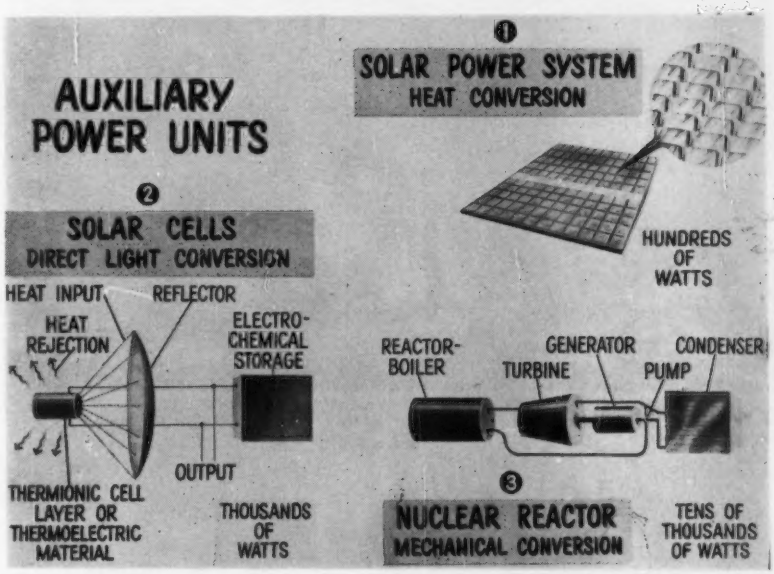
Beyond 1970—Manned flight and landing on moon, and return to Earth.

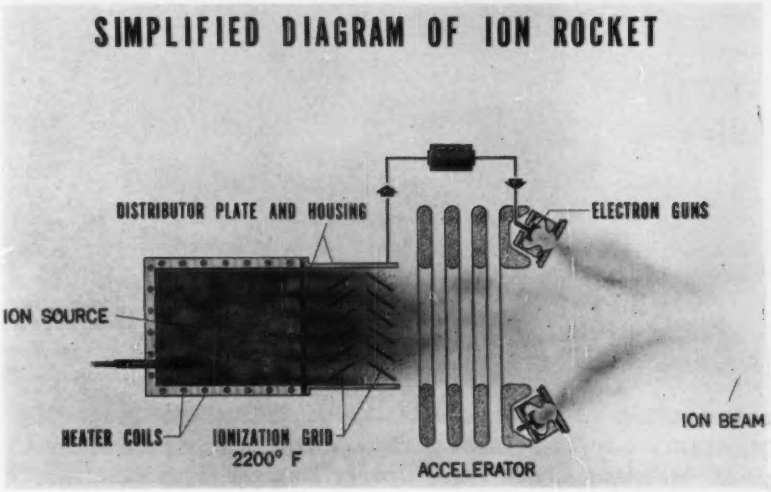
Instrumented Satellites — NASA's design concept for both geophysical observatory and astronomical observatory-type vehicles centers on a standardized unit. Such a standardized unit would use the same structure, the same basic power supply, attitude control, telemetry, and command system for "stock" systems.

In packaging a variety of sensitive scientific instruments and several radio-frequency systems in close quarters, the following problems arise: mutual interference; consistent operation of systems, from a power supply subjected to fluctuations in both the connected load and energy input from solar batteries; "desensitization" — problem of making components and subsystems so stable that their variation in response to changes in pressure, temperature, vibration, acceleration, and radiation becomes negligibly small. To the extent that desensitization goal cannot be reached, active and/or passive techniques must be used to do the job.

Besides the large systems,





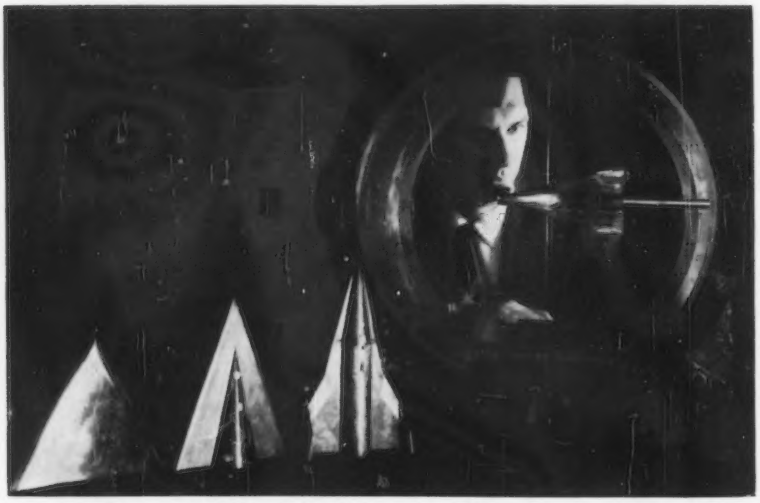


Modular concept for three-man spacecraft Apollo considers support of life in orbit up to 60 days

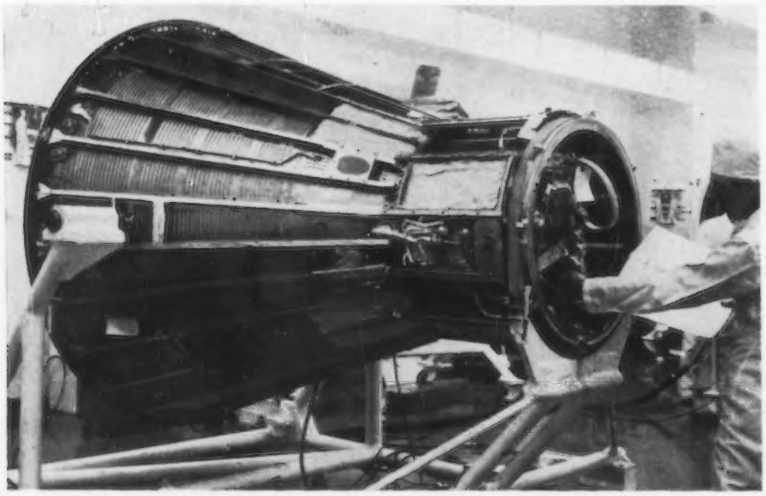
NASA's needs for some typical individual instruments and subsystems include:

- Ion mass spectrometers, vacuum gages
- Radiation detectors and analyzers
- Ultraviolet and X-ray detectors and analyzers
- Directional magnetometers
- Plasma probes
- Telescope pointing controls

NASA feels that the data collection and processing area is also a fertile field for development. In brief, NASA expresses interest in proposals from qualified scientists for experiments in sounding rockets, satellites, instrumentation development and improvement, etc.



HYPERSONIC-GLIDE VEHICLE configurations are shown in NASA's Langley Research Center wind-tunnel. Twin-finned model suggests Dyna-Soar concept.



MERCURY CAPSULE is shown with its inner skin of beaded titanium exposed. McDonnel Aircraft Corp. is prime contractor for capsule.

Planetary Program—This phase covers the unmanned exploration of Mars and Venus, as well as of the interplanetary environment enroute. Centaur would be used first for such purposes, then, in second half of decade — the Saturn. Mercury and Jupiter may also become accessible depending on propulsion development.

Unmanned Spacecraft—for lunar, planetary, and interplanetary missions with gross weights 600 to 1200 lb, the Ranger (A&M Sept. 60, page 21) is being developed. It will be launched by Atlas Agena B. An instrumentation-wise different version—the Mariner—may be used for early missions to Mars and Venus. Other spacecraft under study include: Surveyor, for lunar soft-landing 100 to 300 lb payload with Centaur; Prospector, launched by Saturn, would place mobile lab with 50 mi travel radius on moon; Voyager, launched by Saturn, would orbit Mars and Venus and eject an instrumented capsule. The wide range of environmental instruments needed include: radiation detectors and discriminators; micrometeoroid detectors; pressure, temperature, and ionization gages; sound detectors and analyzers; and mass spectrometers.

Needed are also observational instruments such as: television, for microscopic study as well as scanning of terrain; radar, for surface and in-orbit use; spectrometers of all types; seismometers, magnetometers, penetrometers, chemical analyzers, gravimeters. and microbiological equipment.

Meteorological and Communications Satellites—Based on success

NASA PROJECTED EXPENDITURES 1960-70
$12 TO $15 BILLION (EST.)

Announced Projects (F. Y. 1961)	$ Million
Structures and Materials Research	1.0
Liquid Rockets Advance Technology	6.0
Solid Rocket Development	2.8
Electrical Propulsion Development	3.3
Nuclear Heat-transfer Rockets	5.5
Nuclear Electric-generating Systems	4.5
Sounding Rocket Payloads	5.5
Sounding Rocket Vehicle Procurement	2.5
Satellite Spacecraft Work	33.0
Lunar and Planetary Exploration	75.0
Meteorological Satellites	15.0
Project Mercury	106.75
Advanced Manned Spacecraft	1.0
Satellite Tracking Networks	32.0
Operation of Tracking Networks	44.8
Ground Instrumentation Development	10.0
Solar and Chemical APU Development	4.7
Communication Satellites	5.5
Life Science Programs	5.0

already achieved by Tiros I and II and Echo, others are planned to follow. Nimbus, a 600 to 700-lb meterological satellite, under study, will be put in orbit by Thor-Agena. A stabilization system will keep cameras pointed earthward at all times. Sensors will include television cameras, passive and scan-type radiation-sensing equipment and others.

Aeros meteorological satellite (to be approved) would be put in 23,300 mi 24-hr orbit with Centaur.

Rebound communications-satellite studies indicate that some 12 passive satellites (rigid-type) would be needed for continuous global communications. Atlas-Agena B may be used for Rebound possibly during 1963 to 65.

Recently NASA has also shown interest in the active communications satellites. Initial plans will consider orbiting such satellites 2000 to 6000 mi from Earth.

Manned Space Flight—Last November 21, an attempt made to launch a Mercury capsule by a Redstone booster failed. More launchings are scheduled for early this year. The results of the Mercury program (A&M April 60, page 26) will guide design of the Apollo—a three-man modular spacecraft capable of supporting life in orbit from two weeks to two months. Modular concept will allow multiplicity of missions as needed; Saturn vehicle will be used as booster. Composed of a command center, a propulsion section, and a varying mission module, spacecraft will allow "shirtsleeve" operations for its crew.

Research Programs—The success of the spectacular achievements in the decade ahead will rest firmly on a broad foundation of supporting research. Spectrum of research extends widely from materials to structures, meteoroid impact, re-entry, space propulsion systems, power generation systems, etc.

Presently NASA's Office of Life Science Programs has two major objectives: the implementation of manned space-flight and the conduct of biological investigations related to "extraterrestrial environments." Ramification of these objectives will grow rapidly as man's radius of action extends into space and exposes him to a multitude of environmental unknowns yet to be discoveerd.

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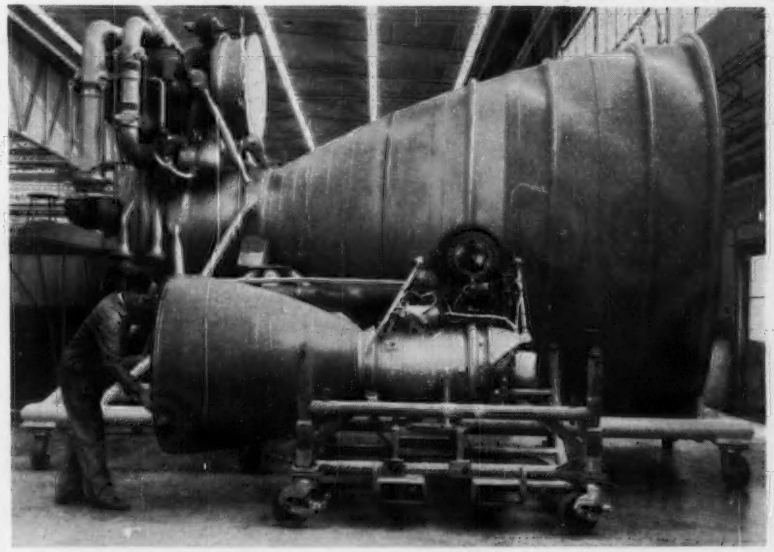
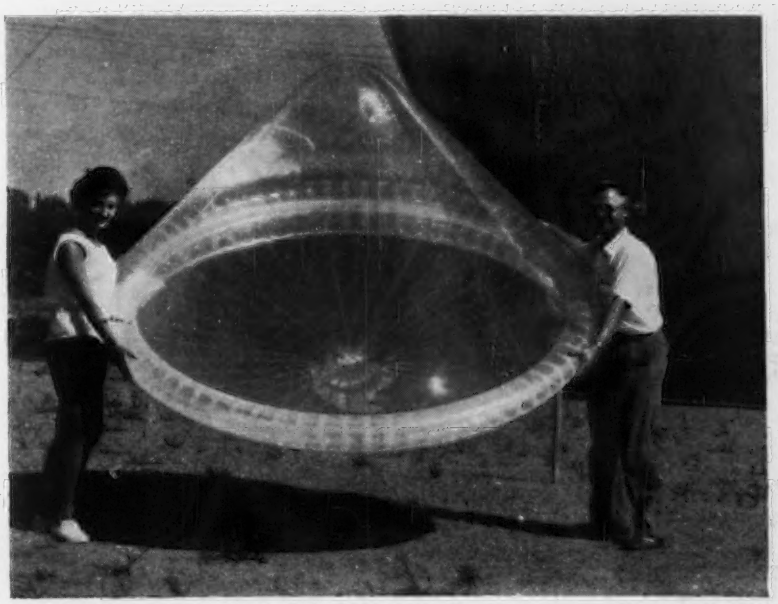


H-1 SATURN ENGINE built by Rocketdyne Div., North American Aviation, is dwarfed by full-scale mockup of F-1 1.5-million-lb thrust engine. The F-1 is being developed, also by Rocketdyne, for NASA.



INFLATABLE SOLAR REFLECTOR is shown in a prototype developed by G. T. Schjeldahl Co. Metalized Mylar parabolic reflector will provide satellite power.

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Thiokol Forecasts Solids For 60's

Thiokol's 1961 advanced planning documents indicate that the next fifteen years will be a period of both evolution and drastic change in the rocket propulsion.

During this period, the evolutionary trend will be best exemplified by a new propulsion requirement—that requirement will be "manned reliability." In terms of rocket reliability, this probably means in excess of 99 per cent.

In the next decade, the crossover point in Government procurement will be reached, and we will spend more money on military and civilian space systems than on terrestrial systems.

Trend To Solids—Dr. H. W. Ritchey, vice president at Thiokol, and the new president of the American Rocket Society says, "The trend in rocketry for the next decade has been established with such systems as the Minuteman, Pershing, Polaris, Subroc, Scout, Bullpup, and the X-15." The simplicity and lower costs of solid propellant units, possibly in the $2-$3/lb range or lower, indicate an almost complete domination of solid-propelled weapon systems for military use. The ease of off-the-shelf staging coupled with high-reliability make solids extremely economical for launching scientific space probes, and earth and weather satellites.

The emergence of the packaged liquid rocket engine — combining the simplicity of the solid with the high-performance of liquid fuels—indicates a continuing market for this propulsion system for air-launched weapons and for small, high-performance ground or sea launched units. The demonstrated capability of the liquid propellant turbopump system for manned flight has been established and man's progress beyond the confines of the earth's atmosphere is ensured."

The Thiokol forecast is divided into two general areas of application and use: terrestrial and space. The decision for this particular separation was made because of the conviction that the propulsion requirements for military and scientific space applications will not drastically differ.

With regard to terrestrial applications for military use, Thiokol predicts that the trend will be towards the development of ballistic weapon systems, both smaller and larger than those currently available. In addition to the requirements for reliability and economy, transportability and mobility will be dominant factors in propulsion selection. Consequently, solid propellant rockets will be the dominant propulsion mode. Moreover, concurrent with the development of these new ballistic missile systems will be programs to develop systems for missile and satellite intercept, and solid system boosters appear most feasible for these purposes.

Role of Liquids — Although Thiokol forecasts that solid systems will dominate for booster applications, there will still be many areas in which liquid fuel rockets will retain certain advantages over the solids. This is particularly true in upper stage applications that require a start-stop-restart or throttling capability. As the development engineering of solid systems moves toward a solution to the problems inherent to providing this capability, liquid development trends will lead toward improvements in the reliability and simplicity of these systems through the use of new concepts and materials for production of tanks, chambers, nozzles, and feed systems. The success of either of these propulsion systems to dominate the other in upper stage application will be determined by how successfully and quickly these concurrent development programs can be completed.

Spherical Rocket — A propulsion concept that Thiokol feels should not be overlooked for upper stage application is the spherical solid propellant rocket engine. The spherical engine offers minimum inert parts weight for a given propellant weight, and mass fractions in excess of 0.95. Since aerodynamic considerations will not be significant factor in upper stage vehicles, the high mass ratio of this design will offer serious competition to other chemical upper stage systems.

Liquid Prepack—The packaged liquid rocket, since it combines many of the best features of both the conventional solid rocket, such as simplicity and reliability, with the liquid rocket's capability to throttle and be re-ignited, will also see many applications in terrestrial military systems. Current studies indicate that this propulsion concept can, for some applications, compete successfully with the solid system even in terms of economy.

Development Work — In the next decade, according to the

Thiokol report, major emphasis in solid technology will be placed on the development of new materials and new propellant combinations that will make such boosters more economical by reducing the cost of inert parts and the costs associated with processing. Plastics and high-strength monolithic materials will be used widely for both case and nozzle parts. New construction methods to take maximum advantage of improvements in the yield strength of these materials will also emerge. Propellant processing with continuous or semi-continuous mix will come into wide use. In addition, new methods to achieve thrust vector control with reduced weight and even a higher degree of simplicity will come into being.

Within the propulsion system industry there is, at present, a controversy as to whether segmenting or on-site construction and loading will provide the most economic means for building the huge solid boosters. Thiokol believes there is a place for both, up to a certain size, providing high-joint reliability can be demonstrated. Ultimately, however, there is a size above which on-site loading, even if clustering is used, becomes necessary. Consequently, the Corporation predicts that several of the case and nozzle fabrication techniques that will emerge during the next fifteen years will be directed toward on-site fabrication.

Recoverable Booster—Another area of interest within the Thiokol forecast is the field of recoverable boosters. Although, to date, recoverable booster systems have been discussed only in terms of liquid rocket engines, the Corporation sees no reason to believe that these same recovery systems could not be used with equal ease on solid rockets. Since the break-even point for recovery of a rocket has been reported by some authorities to be between three and seven successful recoveries, the basic economy of the solid system would indicate that with recovery this system would gain even more of an advantage over its liquid counterpart.

Dr. Ritchey is firm in his belief that liquid propellant rocket systems will play the dominant role in upper stage applications during the next decade at least until non-chemical rocket propulsion systems become operational. He cites the ability to use very high specific impulse liquid propellants coupled with throttleability and on-off capability as major factors in support of this statement.

Off The Shelf Units — During the late 60's and early 70's, a high percentage of the propulsion system advances predicted are predicated on "manned" and logistic space mission requirements. Consequently, just as the majority of sounding rockets in use today result from the clustering and staging of off-the-shelf units resulting from previous propulsion system development programs, many of the logistic systems and navigation, communication, and weather satellites of the future could be propelled to a space target or into orbit by using the off-the-shelf hardware developed during the more advanced space missions scheduled for the 1960's.

Nuclear Rocket — "The nuclear rocket should be a reality by 1970," Dr. Ritchey feels, "and, at that time, large space systems will consist of solid-fuel booster stages, liquid or hybrid middle stages, topped by one, or conceivably more, upper stage nuclear systems. The use of nuclear rocket propulsion systems is one of the keys that will make space travel a reality. Consequently, the early demonstration of an operational nuclear rocket should be one of the prime goals of our national effort in the 60's. Most of the problems connected with perfecting a nuclear rocket have been defined, and the recent NASA/AEC announcement of intent to sponsor development of an operational nuclear rocket is certainly a key step forward."

Electric Propulsion — By the early 1970's, Thiokol predicts that operational electrical propulsion systems of fixed mass and charge will become available. These, ultimately, will be replaced by systems with a variable mass and charge capability. Development of these electrical systems will be heavily dependent on obtaining light weight solid state conversion devices so that nuclear energy can be converted directly to electrical energy. The successful development of these systems will open the door to space travel outside our solar system.

The advances in solid propellant chemistry will result largely from the ARPA National Propellant Chemistry Program. This program is directed toward the development of ingredients such as fluorine containing oxidizers and metal hydride fuels. Using such ingredients the Solid Rocket Industry can formulate practical propellants that will deliver specific impulse values exceeding 300 seconds at standard conditions.

Hybrid Rocket—From current studies it appears that the highest performance rocket oxidizers will be liquid and that the best fuels may be solid. The marriage of such combinations in the hybrid system would be most beneficial. Consequently, the Thiokol forecast indicates that the development of an operational hybrid system is worthy of extensive effort. Work is not far enough along on hybrids to make a prediction on their availability. In addition, extensive fundamental work should be performed to improve the density of the working fluids for nuclear rockets. While the problem of density improvement is formidable, future study of molecular bonding and strained particles may lead to the required results.

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Aerojet Forecasts Liquids For 60's

High specific impulse and long burning time make liquid propellants attractive for booster and "in-space use"; Payload cost reductions in orders of magnitude possible this decade

By Dr. J. C. Moise, Head, Preliminary Design, Aerojet General Corp.

The space age in slightly more than three years old. Liquid rockets have dominated the propulsion scene in both the United States and the Soviet Union. This will continue to be the case during the next ten years for both boost propulsion and "in - space" propulsion. However, propulsion systems will change markedly during this period. Results will be orders-of-magnitude unit-payload cost-reductions.

Specific impulse of currently used and some possible future liquid propellant combinations are listed in Table I. The high specific impulse and the long operating duration of liquid engines permit attainment of high performance and very high total impulse. These factors are important both for boost propulsion and for "in-space" propulsion.

Boost Propulsion—The key to effective space systems is the development and utilization of more economical boost transportation systems. The primary factor in the overall system is the development of relatively large, low-cost, boost propulsion systems since non-propulsion costs, such as guidance, tracking, etc. do not increase rapidly with system size. Two approaches to low, boost system costs are: (a) inexpensive throw-away hardware and (b) effective system recoverability.

Today's propulsion system cost per pound of payload in low altitude orbit are in the $500 to $1500 range. Effective utilization of such boost vehicles as Titan II and others, could reduce this to the $100 to $300 per pound range. Further reductions in payload transportation cost will come through increases in size, utilization of more economical fabrication, quality control techniques, and through recovery.

Table II compares basic characteristics of some chemical liquid rocket, nuclear rocket, and solid rocket boost systems. The take-off weight to payload weight ratio is important in determining boost thrust requirements and launch facility costs. Required boost thrust is important in evaluating liquid nuclear rocket research and development and production cost and to a lesser degree in evaluating the same factors for solid rocket systems. Volume is important in evaluating transportation characteristics and to some extent launch facility costs. Surface area is probably the most important characteristic in determining the cost of the propellant containing component of the system tankage. The pounds of inerts per pound of payload ratio is important in evaluating transportation problems and to some degree in evaluating production cost. Propellant cost is of some significance in throw away boosters, particularly in the case of solids and is of even more importance in high-use recoverable systems.

The results presented in Table II are indicative of the relative merits of non-recoverable launch vehicles suitable for a relatively large number of launchings (50 or more) where production and operational costs start to become predominant. Some conclusions can be drawn based on this table.

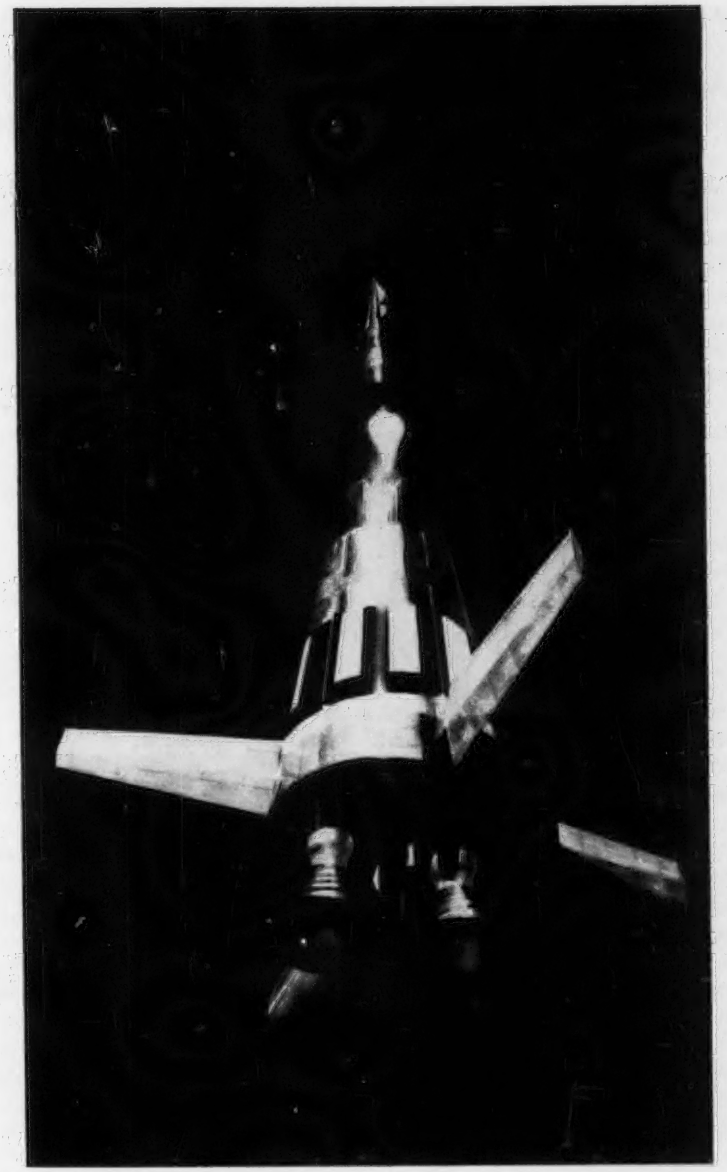
Feed System Type — Pressure fed boosters appear to be unattractive for high-use systems since for the same propellant combination they are larger, weigh more, and require higher thrust than pump-fed

systems. This conclusion is valid up to sizes where development of pumping equipment becomes difficult; or for low-use where the pressure-fed systems may have a lower development cost and shorter development time interval.

Propellant Selection—For non-recoverable boost systems the all O_2/H_2 systems are probably the most attractive since the lower required thrust probably reduces cost more than the decreased surface area of the O_2/RP-1 or N_2O_4/Amine system. An O_2/H_2 second stage shows a larger relative pay off and is attractive in a vehicle using cryogenic propellants. The first stage of a new system should be O_2/H_2 but the argument is not conclusive enough to warrant changing a system under development such as Saturn. N_2O_4/Amine type storables should be used where their logistic operational advantages justify the higher propellant cost. If a storable hypergolic propellant combination with the same performance as N_2O_4/UDMH were available for 5 to 10 cents/lb this combination would be preferred to O_2/RP-1 in all instances, but not necessarily to O_2/H_2.

It is unlikely that a basically new propellant combination will become available in the next ten years which will be sufficiently high in performance and low in cost to displace the O_2/RP-1, O_2/H_2, and N_2O_4/-Amine which are the only combinations currently being used in large liquid propellant rocket engines.

Recoverable Systems—For recoverable systems O_2/H_2 appears to be the most attractive propellant combination primarily because the weight of a recovery system can be added to the booster with a mini-



DYNASOAR BOOSTER is a liquid engine. Early shots will be carried out with a modified Titan. Aerojet sees the chemical liquid rocket engines as doing the workhorse jobs during the 1960's.

TABLE I

PROPELLANT PERFORMANCE
100% OF THEORETICAL

	Specific Impulse, Sec.	
	Sea Level Standard	Vacuum Standard
O_2/RP-1	300	358
N_2O_4/.5 UDMH + .5 N_2H_4	288	341
O_2/H_2	390	457
$O_2/H_2 + B_e$	455	503
$O_2/H_2 + B_e$	496	555

TABLE II

BOOSTER COMPARISON
(Non Recoverable)
50,000 to 100,000 lb Payload to Low Orbit

Propulsion System	No. of Stages	Weight Ratio		Relative Volume	Relative Surface	Propellant Cost Dollars Per Lb of Payload
		Launch/Payload	Inerts/Payload			
O_2/H_2 Pump-Fed	2	14	1.0	1.6	1.3	1.0
O_2/RP-1 Pump-Fed	2	31	1.5	1.2	1.1	0.5
N_2O_4/Amine Pump-Fed	2	30	1.4	1.0	1.0	5–10
O_2/H_2 Pressure-Fed	2	22	2.5	2.5	1.8	2.0
N_2O_4/Amine Pressure-Fed	2	52	4.3	1.7	1.4	9–17
Solid	3	50	4.0	1.1	1.05	25–75
Nuclear	1	7	1.0	3.5	2.3	2

Air liquefying systems such as the LACE promise higher specific impulse than pure rocket

mum effect on system performance. For instance; doubling the inert parts weight of a two stage O_2/H_2 boost system will increase its size 30 percent per stage while the same increase in a O_2/RP-1 system will increase its size 50 percent per stage for the same payload.

Alternate Boost Systems—Solid propulsion appears to be unattractive for high-use due to a much higher metal parts weight, high take-off to payload weight ratio, high propellant cost, and the requirement for more stages. Possible application of solid rockets as boosters may include: (1) parallel staging of simple high thrust solid motors for the first 40 to 60 seconds of boost flight to increase the payload capability, and (2), as a throw away first stage with high energy liquid propellant upper stages provided low cost units can be provided.

Nuclear rocket advantages for boost systems are a lower thrust requirement and the elimination of staging. It is extremely doubtful if these advantages will outweigh the smaller volume, lower propellant cost, and operation advantages of two stage chemical boost rockets. The nuclear rocket has a proper place in space propulsion after the boost phase where the 30,000 ft/sec single stage capability and modest thrust requirement can be best utilized.

Air breathing engines, either turbojet, ramjet, or air liquefying such as the LACE offer the potential of much higher specific impulse than the pure rocket. The disadvantages are higher propulsion system weight, greater complexity and much greater aerodynamic problems during the boost phase. If the aerodynamic problems involved in using an air breather to orbit and return are solvable, the problems involved in returning a two stage rocket utilizing a zero lift boost trajectory are more easily solvable. Rockets are simple and can be developed to the reliability level required for airplane-like operation.

In Summary—Economical boost systems can be obtained by utilizing two stage liquid rockets with costs approaching $30/lb of payload in orbit for throw-away systems and approaching $5/lb of payload in orbit for fully recoverable systems.

By the end of the decade boost systems having low orbit payload capability of at least 250,000 pounds and costs approaching the $5/lb of payload can be available based on known technology. This will be the case only if a well directed program is properly supported.

Chemical liquid rockets will provide the workhorse in-space propulsion during the 60's. The operational AbleStar represents a restartable stage with some of the characteristics of true "in-space" engines. By the end of the decade nuclear rockets and electrical propulsion systems will begin to displace the chemical systems for the high velocity increment missions such as an interplanetary round trip.

In-space rockets are required to perform more sophisticated control functions than boost rockets. These requirements result from orbit matching, lunar soft landing, and similar precise positioning problems.

Two and possibly three basic types of engines are required.

1. A main propulsion system to supply the great majority of the stage velocity increment at high efficiency. Multiple starts and possibly variable thrust will be required. Use of high energy propellants is practically mandatory. O_2/H_2 will be used and possibly F_2/H_2 or $O_2/H_2 + B_e$. Propellant cost is not critical.

2. Vehicle attitude control rockets: A low thrust requirement is indicated but high cycling rates and precise impulse control require reasonably sophisticated design approaches. High performance is important but not to the same degree as in primary propulsion.

3. In some cases a third class of engine intermediate in thrust between primary propulsion and attitude control systems are required. Landing engines for exact impact control on lunar soft landing applications are an example of this intermediate requirement. Propellants will be the same as used in the primary propulsion system.

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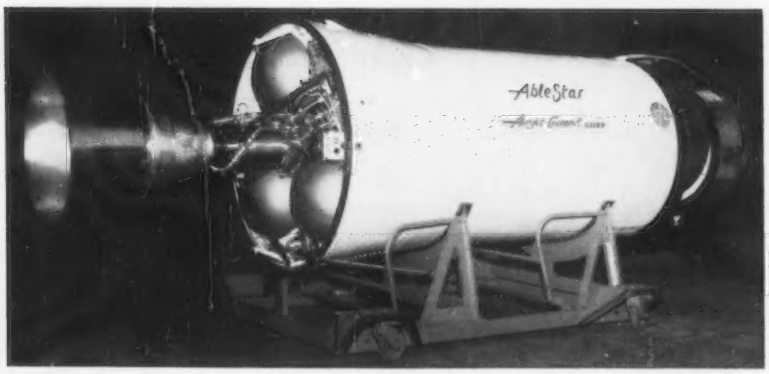

ABLE STAR is operational and represents an engine with some of the characteristics of a true "in-space" vehicle. Aerojet feels that solids have too many disadvantages for space use.

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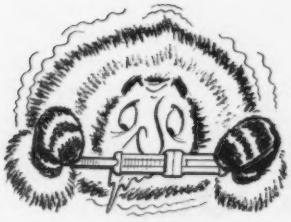
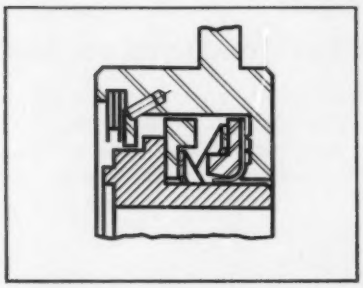
Secrets of Successful Seal Design

Cryogenics - No. 2 of a Series



The sealing of very cold liquids with mechanical seals has opened a new dimension in cryogenics — and, with it, new problems. For instance, many mechanical seals which are satisfactory for liquid oxygen service at –280°F may lose one-half or more of their service life when used with liquid nitrogen at –320°F.



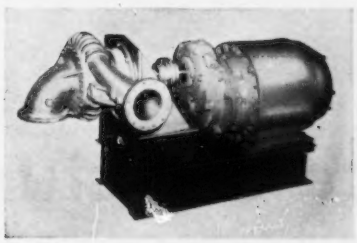
Sealol LOX Seal — *thin film, Kel-F* packing .005" thick, replaces the customary O-ring or V-cup packing, thus reducing axial drag caused by elastomer shrinkage.*

Liquid oxygen, or LOX, is probably the simplest of the cryogenics to handle since it appears to supply some small amount of lubrication, perhaps in the form of an oxide on the faces of the mating ring and seal ring. However, lubrication values of liquid nitrogen and hydrogen are practically nil, and we must select face materials which are designed for "dry" operating conditions.

**TM Minnesota Mining & Mfg. Co.*

HOT OR COLD

It is curious how our technology for solving high temperature, dry-running seals now unexpectedly finds a place at the other end of the temperature spectrum. In both situations, lack of lubrication is at the heart of the problem. Incidentally, our specially treated dry-running seals have met life requirements of 3,000 hours on a shaft turning at 7,000 RPM, ambient temperatures to 250°F and intermittent pressures to 650 psi when water was pumped for two minutes once every four hours.



Equipped with standard Sealol LOX Seal, *this 500 GPM centrifugal pump is part of skid-mounted LOX ground support equipment manufactured by the Cambridge Division of Standard Steel Corporation. Discharge pressure is 100 psig max., 2380 RPM operating speed.*

SEAL LOCATION

Pump design and general operating conditions will have a lot to do with seal performance when handling cryogenics. Provide, if you can, for the seal to operate directly in the liquid being sealed. This will give you the benefit of whatever lubrication value the fluid has, plus better heat transfer conditions, and is usually preferable to sealing the gases themselves. When the seal is operating in the vapor stage, the temperatures ambient to the seal are usually slightly higher than if the seal were immersed in the fluid.

APPLICATION REQUIREMENTS

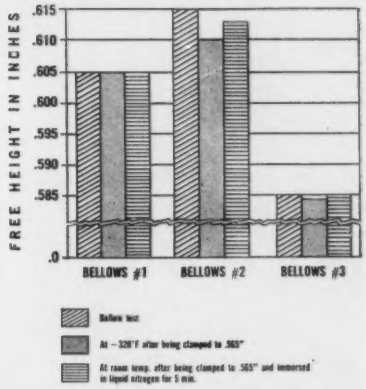
Our missile customers usually think of seal life in terms of minutes and seconds, or at the most, in hours. On the other hand, our industrial customers want LOX transfer pump seals to stand up for years. In the latter case, speeds and pressures are considerably lower, and under favorable conditions, a life of 1,000 hours is certain.

At high rubbing speeds, say 10,000 fpm and more, "burn" marks are frequently observed on the rubbing surfaces of the seal and mating rings in spite of the fact that the temperature of the cryogenic being sealed is hundreds of degrees below zero.

High spring loads will frequently be the villain behind this curious phenomenon. Seal designers have been leaning towards higher spring loads in order to overcome the drag caused by stiffening of the elastomers at low temperatures. If you notice burn marks on your mating rings, check for excessive spring loading in relation to face rubbing speeds.

BELLOWS SEALS

Sealol balanced-pressure bellows seals, on the other hand, provide a positive answer to this problem because metal bellows offer no temperature induced resistance to axial movements as do elastomers. As a result, spring loads can be reduced to any level consistant with optimum face loading.



Cold-soak tests *have indicated that bellows spring characteristics (Stainless #300 Series Steel) remain unchanged for all practical purposes, before, during and after immersion in cryogenic liquids.*

We have learned the hard way that there are no pat answers to problems involving cryogenics, because each requires special consideration. We'd be glad to exchange information and, if you wish, submit a proposal for your specific problem.

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Aerospace Structures Gap

Choice of vehicle structures limited by dearth of conclusive data on space environment; Tests urged to simulate meteoritic impact, solar heat, and hard vacuum

By Dr. Seymour Lampert, Manager Aeromechanics Dept., Aeronutronic Div., Ford Motor Co.

Having set our initial goals in space exploration, we are now facing the unknowns of a vast and enigmatic environment.

What is the make-up or content of the regions beyond the confines of our atmosphere? Current state-of-the-art can offer no definitive answer to this pressing question. Scanty information gathered thus far, however, indicates early problem areas imposed by radiation zones and the vacuum of space.

This article will confine itself to design considerations of space-vehicle structures, related to the launching and the space phases of the mission.

Present multi-wall design concepts for space structures include: (1) rigid, (2) non-rigid inflatable, and (3) semi-rigid structures of the inflatable type. Of these, the rigid structure appears to be the most reliable concept for the initial manned vehicles. The large number of unknowns involved make it difficult at this time to reliably assess the capability of the more-exotic, expandable structures.

Information on human as well as material tolerances, from various environmental inputs must now be established. Ignorance of these inputs tends to place limitations on the selection of orbits and the duration of missions. Requirement for continuous or intermittent human occupancy imposes additional structural constraints. Orbit and vehicle orientation should be selected to minimize anticipated hazards and to provide for creature comfort. Some guiding principles in selecting a structure for continuous human occupancy up to 30 days in orbit follow:

(1) An optimum structural configuration should be chosen to endure mechanical loads imposed by boost, and fulfil pressure-vessel requirements in space.

(2) The design should incorporate structural shielding against meteoritic penetration and cosmic radiation. To minimize effects of a penetration, the design should incorporate fail-safe measures against crack propagation and/or explosive failures.

(3) In light of item (2), definitive information relative to these environments must be acquired, and structural weight penalties assessed for environmental safeguards.

(4) Since solar radiation and infrared radiation are of major

concern, a surface finish should be selected to provide the proper heat balance for an inhabitable internal environment.

(5) Material selection should be guided by what is readily available or promising. It is well to recognize that the strength for weight advantages predicted by launch and boost requirements are not the criteria in space where lightweight may be governing; hence, a proper mating of these functions must be reflected in the design.

(6) Tests should be performed to check material behavior under meteoritic impact, solar heating and hard vacuum.

(7) Methods for detecting and repairing leaks for sealed cabins must be developed.

Areas for Investigation—An investigation carried out by Aeronutronic for WADD (Contract No. AF 33(616)-6641) has led to conclusions indicating how these principles may be adhered to. Areas requiring more definite information or further investigation are described below.

Related to meteoritic problem, the need exists for knowledge of inputs, and response of structures and materials. Analytical methods for determining vehicle structural requirements fall into: (1) pressure-vessel requirements, (2) structural-stability requirements, and (3) shielding requirements. In each of these categories the analysis is based on the knowledge of inputs (loads —as determined by the mission and the environment), and knowledge of system response (structural response).

With regard to pressure-vessel function of structure, knowledge of both inputs and response is adequate enough to yield a design of reasonable reliability. Shielding design, however, is hampered by inadequate knowledge of both environments and material response.

With regard to structural stability requirements, inputs can be defined with reasonable accuracy. However, for complex structural geometries, stability calculations are complicated by serious analytical difficulties. Therefore, certain conservative approximations must be used. This implies a weight penalty. But, it is important to note that for multi-wall geometries, the designs of outer and inner walls are governed by shielding and pressure vessel requirements; the stability analysis determines only the core configuration. Hence, the weight penalty will be reflected only in the weight of the core, which can be expected to weigh a fraction of the total structure.

Thus, the minimum weight of space vehicle structures is mostly dependent on the meteoric shielding and pressure vessel requirement. The meteoric environments, the load inputs, and the combined material and structural responses require the greater attention in structural tests.

The static response of a pressurized structure is adequately defined by established methods of analysis; however, certain fail-safe design information on multi-wall structure is needed. A detailed understanding of crack propagation and explosive-failure phenomena in typical structures from 500°F to —300°F is of urgent importance.

Cosmic Radiation—Need exists for energy spectrum of various particles, tolerance levels for human occupant, effect on materials, and attenuating characteristics of materials.

Radiation (both in and out of Van Allen belts) must be considered in planning manned exploration.

DOUBLE-WALL CAPSULE for manned space exploration is shown in artist's conception; space station and winged re-entry vehicle are seen in background. Design is by Space Technology Operations team, Aeronutronic Div., Ford Motor Co.

Purpose of each manned orbital flight will influence design of structure and shielding

Extent of this radiation may determine the length of time an individual may remain outside of the Earth's protective atmosphere. The purpose of each manned orbital flight will influence the selection of structural and shielding materials, as well as the thicknesses needed.

Lack of precise knowledge of this expected radiation for a chosen orbit leaves in the design and shielding a very large margin of uncertainty. To minimize this uncertainty a detailed mapping of the radiation surrounding the Earth is required. This should be done from about 300 km to as far out as practicable, including the Van Allen belts. Consideration must be given to the types of radiation, also to steady-state conditions (if such exist) as well as variations from this steady state. A study of the frequency and magnitude of any variations and their causes may reveal favorable flight periods with a minimum of shielding. The gathering, reduction, and compilation of the above data is being done to some extent through NASA's NERV and Scout programs and the Air Force Blue Scout.

The theory of energy absorption and beam attenuation by matter to several types of radiation has been fairly well developed and substantiated experimentally. However, radiation attentuation must be plotted as functions of thicknesses and materials for satellite walls and special shielding structures. This would enable the satellite designer, and the shielding specialist to determine optimum combinations of materials and wall thicknesses needed for space crews and sensitive equipment.

Materials Problems and Test Requirements—In addition to crack propagation and structural explosive tests, creep studies are needed of dual-wall pressurized structures, as well as simulated environmental tests on materials and dual-wall pressurized specimens.

Current state-of-the-art indicates that some mechanical properties change after exposure to high vacuum, but the direction and magnitude of change are not well defined. Vacuum environments utilized thus far are equivalent to a 100-300 mile orbit.

It might be desirable to study vibration fatigue, creep, impact strength and coefficient of friction under vacuum conditions approaching 1×10^{-12} mm Hg. Vibrational fatigue will be considered since any motion inside a space vehicle will impart more or less undamped vibration to the whole structure. Because of the existence of continuous low-level tensile loading and elevated temperature (400°F on solar oriented sides) creep can become a problem and should be investigated. Impacts will occur from collision with micrometeorites which have been measured as large as 8 cm in diam weighing 10^4 gm. Assuming that any named satellite will have components containing moving parts, coefficient of friction becomes a problem. It is recognized that adsorbed gas films impart a beneficial effect to friction and wear properties. Such films will be absent in a space environment and seizure and welding can occur through molecular bonding. These effects may occur even in such a simple operation as threading a bolt in a hole. Repair or self-sealing techniques should be developed for various materials exposed to severe vacuum.

Consideration should also be given to effects of space environment on physical properties of materials. Current concepts indicate that similar effects on mechanical properties of materials may be of secondary importance. A region of prime importance and concern is surface of the outer shell of any space vehicle. This surface is subject to extreme conditions of vacuum and radiation. The extent of chemical stability of the material comprising the structural outer shell, during long exposure to space environment is yet to be determined. Therefore, there is need to study such affects as the dissociation of nitrides, carbides and oxides on the surface of structural metals.

Of equal importance are environmental effects on adsorbed gases and dissolved gas in the lattice, depending on material. Another important aspect for consideration is the effect of high vacuum on the lower-boiling-point alloying elements in a structural metal. All of the above phenomena will alter strength or mechanical properties as well as the desirable surface conditions.

Space parameter imparting the greatest effect on the described surface conditions is high vacuum. It is also the condition which can most accurately be reproduced in earth-situated laboratories. Suitable structural and coating materials such as aluminum, magnesium, titanium, steel, refractory oxides, and cermets should be exposed for suitable time intervals to extreme vacuum under various conditions of temperature. Indications are that pressures below 1×10^{-9} mm Hg are required to study such surface effects. Current vacuum technology allows pressures approaching 10^{-12} mm of Hg and systems capable of such high vacuum would prove invaluable at this time. Effects of temperatures varying from –70 to 400°F should also be investigated. Weight loss, micrographic and chemical analyses investigations should be conducted involving exposures of several weeks to the environment required.

Thermal Control — Structural weight trade-off studies between insulation weights and radiation control devices for various missions

and durations are of particular interest.

To-date, insufficient data are available on the effect of ultra-low vacuum on materials to be used for passive temperature control of space vehicles. Sublimation and ionization of surface materials subjected to high vacuum may considerably change the optical properties of the surface as well as seriously reduce the useful life of these surfaces. Super-imposed on ultralow vacuum phenomena is the possible surface degradation due to radiation, micrometeorite impingement and sputtering. Use of surface coatings to control heat transfer and, thus temperatures in outer space vehicles is important due to inherent simplicity and low weight.

Depending on the particular orbit and mission of a given space vehicle, the required thermal radiation characteristics of surfaces may change. In one case, maximum reflection of solar radiation and maximum absorption of infrared radiation may be required. In another case, the maximum reflection or absorption of all wavelength radiation may be required. Severe outer surface temperature gradients can occur if no attempt is made to control the emissivity and absorptivity of the surface. The temperature of a thin walled polished aluminum surface could vary from several 100°F in a region (500°F) to several 100°F below zero in another region.

Lastly, a program should be initiated to determine optical characteristics of several promising materials when subjected to ultrahigh vacuum for various periods of time. Whenever feasible, these surfaces should also be subjected to simulated space radiation and particle environments to more realistically determine the state of the surface in an outer-space environment. Information of this type would be useful in evaluating the requirements for environmental control within the pressure vessel.

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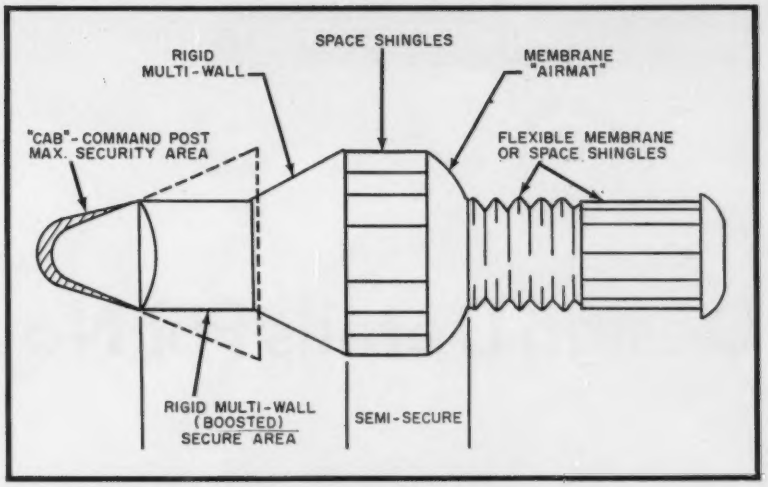
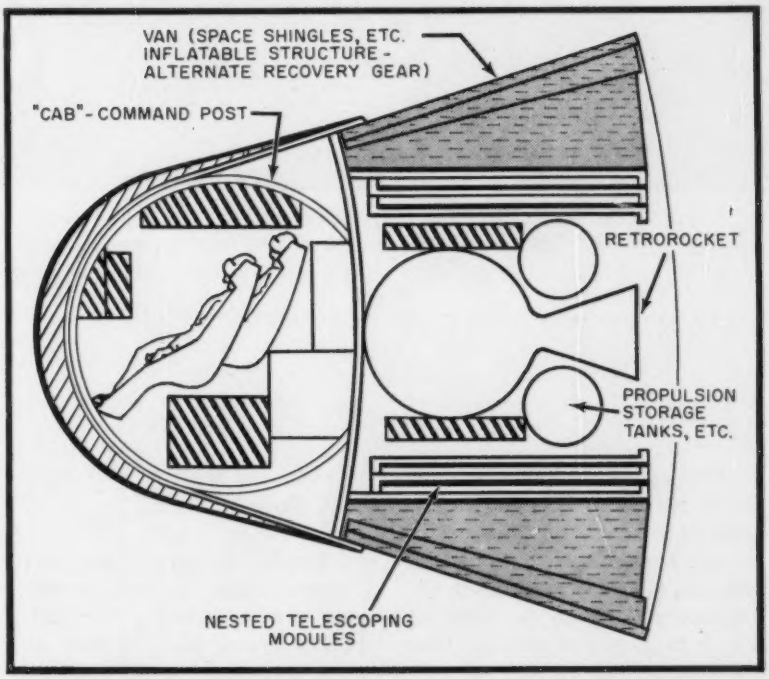


TELESCOPED MODULE concept proposed by Aeronutronic incorporates space-saving feature for manned capsules.


VAN (SPACE SHINGLES, ETC. INFLATABLE STRUCTURE - ALTERNATE RECOVERY GEAR)
"CAB"-COMMAND POST
RETROROCKET
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NESTED TELESCOPING MODULES

"CAB"—COMMAND POST features are outlined for a typical re-entry capsule.

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Design Details For Nova's Booster

Single chamber F-1 engine develops 1.5 million lb thrust, Enhances liquid propellant dominance in boosters through late 60's; Thrust chamber uses cooled and uncooled sections

By David E. Aldrich, F-1 Program Manager and **D. J. Sanchini,** Asst. Program Engineer, Rocketdyne Div. of NAA

Payloads planned for Earth orbit in the late 1960's are in the order of hundreds of thousands of pounds. For lunar landings and return, and for planetary orbiting, the payloads will be on the order of tens of thousands of pounds. During the later part of the decade it is expected that manned space laboratories will be established and will require repeated missions to renew supplies and change personnel. The vehicle accomplishing these jobs will be Nova, successor to the Saturn. Nova will use clusters of the giant F-1 engine in its first stage booster. F-1 is a single chambered 1.5 million lb thrust engine that uses liquid oxygen and RP-1 as a propellant combination. Clustering F-1 will give Nova 9 to 12 million lb of thrust at takeoff.

Engine Design — Basic components of the F-1 are a tubular-wall thrust chamber, a direct-drive turbopump, a gas generator, and their controls. Engine weight is about 15,000 lb.

For simplicity and compactness, the turbopump is mounted directly on the thrust chamber.

All other components are also mounted on these two assemblies, or are in the plumbing system between them. When the engine is gimbaled, the high-pressure ducting is not flexed. Thrust vector control is achieved by gimbaling the entire engine. The high-pressure fuel is used as the hydraulic actuating medium.

Thrust Chamber—Thrust chamber on the F-1 consists of a tubular-wall, regeneratively cooled chamber with an uncooled extension, a double-inlet oxidizer dome, four integral fuel valves, and a flat-face injector.

The cooled portion of the thrust chamber extends to a 10:1 expansion area ratio. Its approximate measurements are: combustion chamber, 40-in. diam; nozzle exit diam, 9.5 ft; and length, 11 ft.

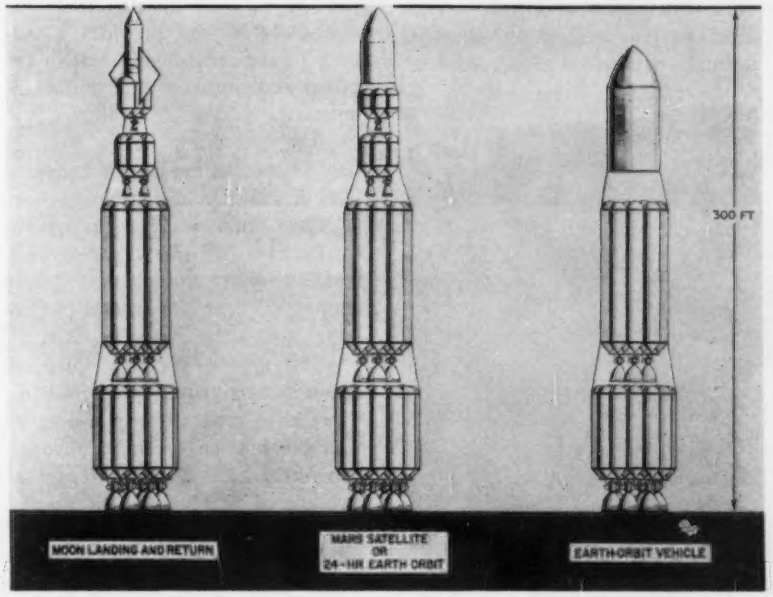
The chamber is designed for the attachment of segmented, uncooled extensions. This facilitates transportation, and allows any expansion area ratio up to 16:1.

SPACE PLATFORMS are envisioned by some planners before the end of the 60's. Using spent sections of the huge Nova vehicle is one projected way of building such a platform. Nova will follow Saturn in NASA's development cycle for big boosters. Preliminary Flight Rating Tests will start in 1962.

Two tons per second of liquid oxygen and nearly one ton per second of narrow-cut kerosene (RP-1) are burned in the combustion chamber.

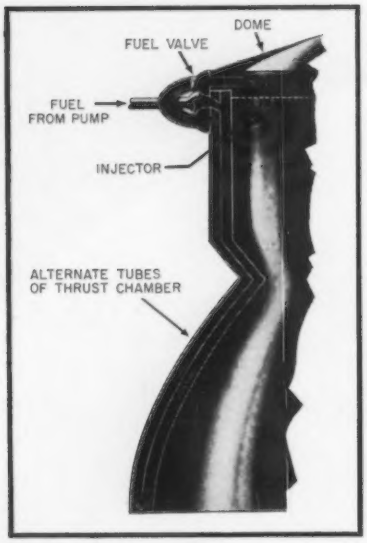
The oxidizer is fed through dual inlets to the dome to assure even distribution to the injector. The oxidizer passes through feed holes, and is injected through a pattern of 2600 orifices into the combustion chamber.

The fuel is also fed through dual inlets to a chamber fed manifold (see illustration). It then flows through alternate tubes for the length of the chamber, and returns to the fuel collector manifold. The flow then continues through four



NOVA VEHICLES will be powered by a first-stage cluster of F-1 engines. Thrust will be about 9 million lbs. Configuration on right could loft 400,000 lb payload into low Earth orbit. Configurations at left and center could put about 90,000 lb in Mars orbit.

Valves and controls use propellants as hydraulic medium; Engine to have 18,000 sec ground test by early '63



THRUST CHAMBER is cooled by RP-1 which flows through alternate tubes in chamber wall. Fuel is fed through dual inlets to a chamber feed manifold before entering the tube wall. Oxidizer is fed through dual inlets to the dome to assure even distribution at injector. Oxidizer enters combustion chamber through pattern of 2600 orifices.

INJECTOR TESTS were carried out with heavy inexpensive thrust chamber. Injector was major design hurdle. Took year and half to evolve stable configuration.

fuel valves spaced at 90 deg around the chamber into an injector feed manifold. This manifold distributes the fuel through 32 spokes into the injector, from which it passes through approximately 3700 orifices into the combustion chamber. The location of the valves downstream of the chamber provides a greater degree of control in timing and sequencing the fuel for engine starting. It also provides a repeatable minimum cutoff impulse.

Turbopump—In the interests of simplicity and reliability, the turbopump is a direct-drive unit. The fuel and oxidizer pumps are driven by a velocity-compounded turbine.

The turbopump, operating at rated conditions, will develop approximately 60,000 horsepower. The assembly is approximately 4 ft in diam, 5 ft in length, and weighs approximately 2500 lb.

Oxidizer is supplied to the pump through a single inlet, in line with the main shaft, and is discharged radially through dual outlets. The dual-outlet design provides a balance of the centrifugal loads in the pump and minimizes the pump diameter.

The fuel pump design includes dual inlets and outlets for balanced load distribution and minimum size.

Gas Generator—The gas generator burns a fuel-rich liquid oxygen and kerosene mixture. It burns about 2 percent of the total propellants used in the engine.

The unit is partially spherical and is approximately 10 in. in diam. The design makes use of a double-wall combustion chamber, through which the fuel flows to regeneratively cool the body. This feature adds to the safety of the engine by eliminating a hot outer surface which could ignite leaking propellants, and it reduces heat radiation to adjacent components.

Controls — The main controls are: four fuel valves, integral to the thrust chamber assembly; two oxidizer valves mounted on the thrust chamber dome; a gas generator valve; a fuel and oxidizer flow regulator for the gas generator; and a four-way solenoid valve. This four-way solenoid valve is one of the only two components in the engine requiring electrical wiring or energy; the other component is the spark exciter for gas generator ignition.

The fuel, oxidizer, and gas generator valves use propellants as their hydraulic actuating medium. The oxidizer and fuel valves are of the poppet type. The poppet eliminates the turning moment associated with large butterfly valves, simplifies sealing problems, and minimizes the package size.

The high-reliability goal required for manned space exploration will be achieved using concepts that are already well proven.

Engine System—The first engine is scheduled to be tested early in 1961. The components being assembled into this engine have completed hot firing and bench tests.

The first phase of the engine program will consist of short-duration tests to perfect the engine start and shutdown sequences. These tests are followed by performance, durability, repeatability, and reliability programs, all designed to prepare the engine for the start of the Preliminary Flight Rating Test in late 1962. The engine, after approximately 18,000 seconds of development testing, is scheduled to complete PFRT tests in early 1963.

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Abstracted from "The Development Of High-Thrust Engines For Large Vehicles," presented at 15th Annual Meeting of American Rocket Society, Dec., 1960.

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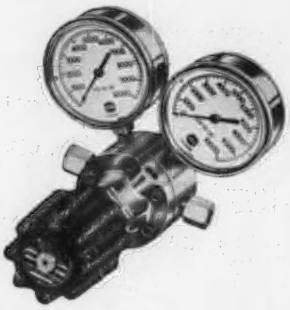

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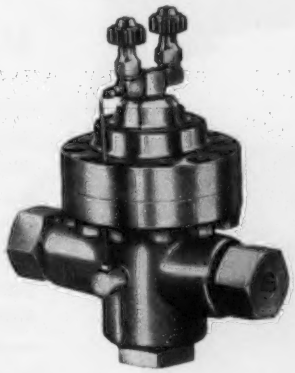

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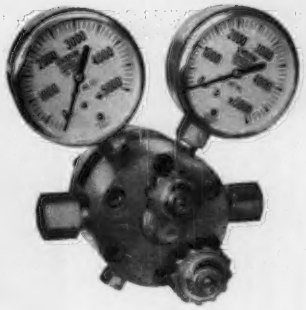

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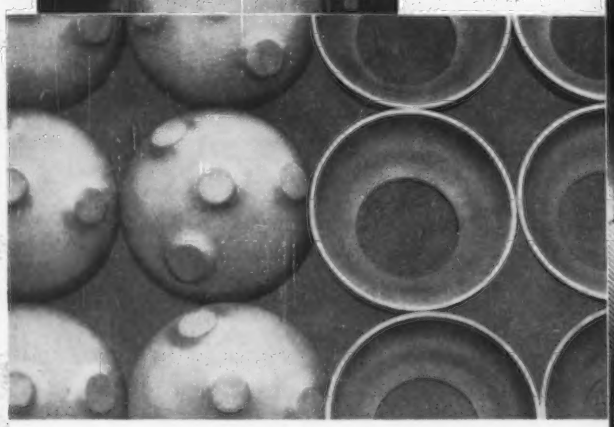

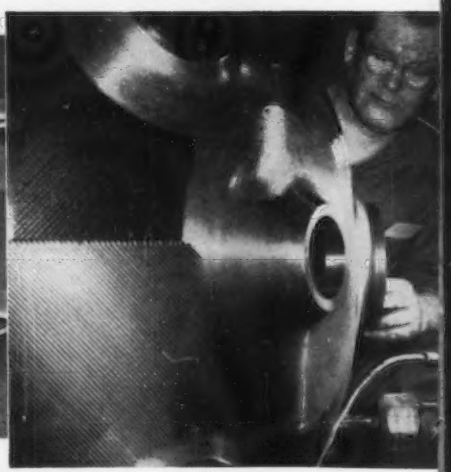

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of Aluminum Magnesium Steel Titanium . . . and Beryllium Molybdenum Columbium and other uncommon materia

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Can DOD Seize Patent Rights?

Robbins Aviation Inc. protested Air Force's removal of patent legend from company drawings, Persisted under heavy odds, and "beat city hall"

This is the fourth article of a series discussing the procurement policies, and practices in the Department of Defense (DOD). The two are often at variance. Discussions have centered around that section of ASPR which deals with proprietary and patent rights. Small business in particular feels that the over zealous implementors of well intended government regulations are practicing illegal and confiscatory methods.

This month in "Can DOD Seize Patent Rights?" we have the account of a small Western firm's courageous and victorious battle against Air Force who threatened to remove a patent legend from company drawings. The case could well set a precedent.

Other articles that have been published by Aircraft & Missiles are:

- *Vicious Procurement Practices in DOD?*
- *DOD Talks Back*
- *We Tried To Do Business With DOD*

As a result of industry-wide dissatisfaction with the Armed Services Procurement Regulations certain revisions have been proposed to Part 2, Section IX; Part 3, Section I; and Part 1, Section IX. Mr. Hugh C. Robbins comments on the ASPR as amended, " . . . it is in direct conflict with the precepts of the Constitution. The 'seller'—the person with the intelligence to create—is placed on the defensive by every statement in the regulation. The very creativeness the Government says it is trying to encourage will be completely nullified unless the 'creator' is protected without having a staff of attorneys constantly at his elbow . . . "

Hugh C. Robbins . . . On the defensive . . .?

The efforts of DOD to secure unto itself engineering data developed by industry, has caused contractor woes for many years. But in recent months, even a non-contractor has felt the confiscatory grasp of the tentacles on the Armed Forces Procurement Regulations (ASPRIX).

Robbins Aviation Inc. learned one day last summer that Air Force had seen some Robbins' blueprints, and that Air Force liked what it saw. So much so that it intended to make these drawings a part of the bursting AF library, and that it intended to use the drawings as it saw fit. Now, throwing confiscated prints out to competitive bid has

"Sometimes it pays to fight city hall"

been practiced in the past and is a generally conceded fact of life in doing business with DOD. But Robbins was having none of this, and the small company's president, Hugh Robbins, came out swinging. The events in the five months that followed prove that contrary to general sentiment, "it does pay to fight city hall."

Robbins became involved when it sold some patented, commercial valves to Victor Equipment Co. Drawings and data on the valves were included to aid Victor in receiving and inspection. Victor subsequently sold these valves to Convair, a division of General Dynamics since they met specifications on a Convair requirement. Convair was involved in a contract with Air Force [AF33(600)36546] which gave the U. S. Government unlimited rights to all data and drawings generated under the contract.

The original "receiving and inspection" drawings supplied by Robbins wound up in Air Force custody. And then Air Force saw something it didn't like. Each of the drawings contained this legend:

"Th drawing is the property of Robbins Aviation, Inc. and may be reproduced only for use in connection with identification and inspection. Patent 2917271 Patent Pending."

Then started a very interesting series of correspondence. Air Force advised Convair and Robbins (July 19).

". . . The government hereby notifies you that delivery of the foregoing drawings was not in compliance with the terms of the "Data" clause of the above referenced contract. Accordingly, the Government feels free to delete the restrictive legend from the drawings and to utilize them in whatever manner is consistent with the Government's best interest."

Robbins took exception to this letter and wrote to Air Force (August 12).

". . . it might be well to admonish you that Robbins Aviation Inc. is neither a contractor nor a subcontractor within the provisions of ASPR IX, Part 2. The items involved (the valves) are patented commercial cataloged products having price lists that are offered and sold to the public in general, as proprietary items."

Robbins then advised Air Force it would take certain legal steps to reverse the decision to remove the restrictive legend. Air Force was asked to supply in ten days answers to the following questions so that Robbins might perfect its defense.

"1. On what authority is Robbins Aviation, Inc. classified as a contractor or sub-contractor within the terms of the Act?

2. Where does a stock and commercial item such as the product involved fall within the purview of the Act?

3. In what manner does the Government intend to use the engineering drawings of Robbins Aviation, Inc.?

4. Is it intended to appropriate the 'Trade Secrets' of Robbins Aviation Inc. and distribute them for competitive bidding among its competitors?

5. Is the deletion of the restrictive legend and the future utilization of the products by the Government to be done without any legal basis therefor?

6. What investigation has the Government made to determine its jurisdiction to make such seizure?"

This was a bold, almost brash, request. The exact answers never came. But the questions set Air Force thinking. They wanted to get the matter straight in their own minds. In a letter dated August 18, Air Force asked Convair to conduct an investigation as to the . . . "acquisition of subject drawings. Such drawings were furnished by Convair to USAF under the 'Spare Parts Document Correction Sheet' (AMC Form 296) . . ."

Convair replied on September 6 that the drawings were obtained from Victor Equipment Co. which granted Convair unlimited rights.

This tossed the ball in the unsuspecting lap of Victor. Convair was convinced its own record was clear and hesitated to investigate further.

On Air Force request, Victor looked into the matter and on October 12, dispatched the following telegram to Lt. Col. David C. Yoeman, USAF Staff Judge Advocate:

"DRAWINGS PACKAGED WITH MATERIAL SUPPLIED ON ABOVE PURCHASED ORDERS WERE FOR RECEIVING INSPECTION AND IDENTIFICATION "ONLY." VICTOR EQUIPMENT DOES NOT HAVE UNLIMITED RIGHTS TO THESE DRAWINGS. WE ARE DEALERS OF ROBBINS PRODUCTS AS WELL AS OTHER PRODUCTS INCLUDING THOSE OF OUR OWN MANUFACTURE. WE OPERATE AS AN INDEPENDENT CONTRACTOR BUYING FROM ROBBINS FOR RESALE TO OUR CUSTOMERS."

Then Robbins got the message that it wanted to hear. A message that will hearten many small business firms. Air Force retreated, on October 13 they wrote to Robbins. . . . "On the basis of the attached telegram, this headquarters will not delete the restrictive legends from the engineering drawings of Robbins Aviation Inc."

Robbins had fought City Hall . . . and won.

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—Used in piping on fueling lines handling liquid oxygen, JP4 and JP5 fuel, white and red fuming nitric acid, and other chemicals.

—Provides swivel motion to allow for thermal expansion and contraction.

—High corrosion resistance. Other special designs available. For temperatures from −320°F. to +1,000°F., and higher. Also joints for gas and hydraulic service.

Patent Pending

(Right) 6"—180° flanged Barco Flexible Joint for use in fueling line handling liquid propellant. Also straight and 90° designs.

AIRCRAFT DIVISION

BARCO *Serving Industry Since 1908*
MANUFACTURING CO., 565B Hough St., Barrington, Illinois

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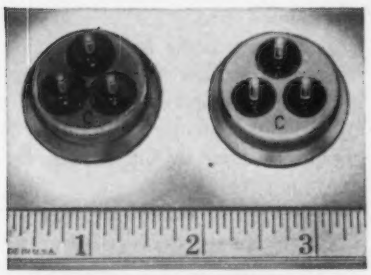

FUSED GLASS AND METAL MISSILE PARTS CLEANED QUICKLY AND WITHOUT DAMAGE TO GLASS GLAZE *with* VAPOR BLAST

Liquid Honing

Vapor Blast Liquid Honing process cleans metals fused to glass without removing glaze or damaging the glass.

Yet the metal parts are thoroughly cleaned, burrs removed, in shortest possible time.

Bring or send parts for test cleaning. No obligation.

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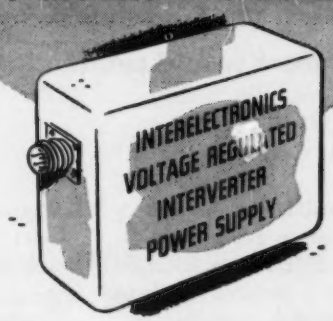
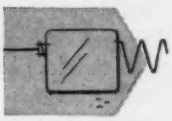
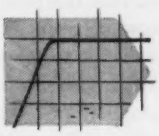
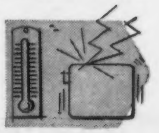
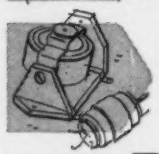
SOLID-STATE POWER INVERTERS, over 260,000 logged operational hours—voltage-regulated, frequency-controlled, for missile, telemeter, ground support, 135°C all-silicon units available now—

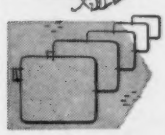












Interelectronics all-silicon thyratron-like gating elements and cubic-grain toroidal magnetic components convert DC to any desired number of AC or DC outputs from 1 to 10,000 watts.

Ultra-reliable in operation (over 260,000 logged hours), no moving parts, unharmed by shorting output or reversing input polarity. High conversion efficiency (to 92%, including voltage regulation by Interelectronics patented reflex high-efficiency magnetic amplifier circuitry.)

Light weight (to 6 watts/oz.), compact (to 8 watts/cu. in.), low ripple (to 0.01 mv. p-p), excellent voltage regulation (to 0.1%), precise frequency control (to 0.2% with Interelectronics extreme environment magnetostrictive standards or to 0.0001% with fork or piezoelectric standards.)

Complies with MIL specs. for shock (100G 11 misc.), acceleration (100G 15 min.), vibration (100G 5 to 5,000 cps.), temperature (to 150 degrees C), RF noise (I-26600).

AC single and polyphase units supply sine waveform output (to 2% harmonics), will deliver up to ten times rated line current into a short circuit or actuate MIL type magnetic circuit breakers or fuses, will start gyros and motors with starting current surges up to ten times normal operating line current.

Now in use in major missiles, powering telemeter transmitters, radar beacons, electronic equipment. Single and polyphase units now power airborne and marine missile gyros, synchros, servos, magnetic amplifiers.

Interelectronics—first and most experienced in the solid-state power supply field produces its own all-silicon solid-state gating elements, all high flux density magnetic components, high temperature ultra-reliable film capacitors and components, has complete facilities and know how—has designed and delivered more working KVA than any other firm!

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An Aircraft & Missiles / **SPECIAL REPORT**

Britain's Role In Space

Hawker Siddeley suggests global satellite-communications; Effort would sustain Britain's aerospace technology

By Ronald A. Cole

It is impossible for the British to undertake space exploration on a scale comparable to that of larger nations. But it is possible for them to make worthwhile contributions.

In the past, the small nations have shown the ability to produce advanced ideas and hardware. Examples of nuclear weapons, high-speed aircraft and advanced electronic devices have proved this point. Working on a small budget inevitably means a time lag behind the wealthier nations, but it does not influence the quality of the product.

Britain has a large industry and export market based on communications equipment. This background would be a logical one to utilize for research in global communications via satellites.

When work on the Blue Streak IRBM was halted in favor of the Douglas Skybolt, all active design and development work on large rockets ceased. During the past months the program has been kept turning over at a very slow pace, purely it seems to provide test data. Although the missile has never been launched it has shown sufficient promise for use as the first stage of a satellite carrier. Calculations indicate that the Blue Streak compounded with a Black Knight second stage, plus a small third stage could orbit satellites weighing up to 800 lb in a 300 mi orbit.

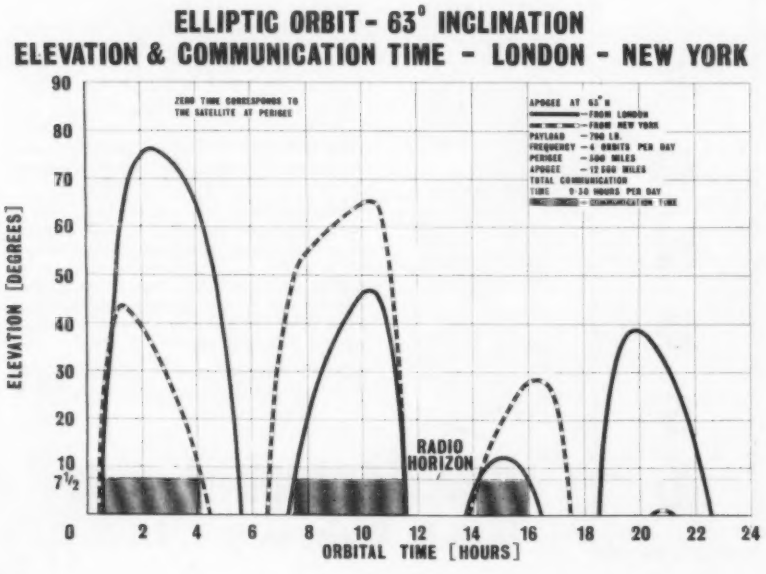
It is the contention of the Hawker Siddeley combine that the government should provide funds for the continuation of the project along these lines. Such a program would make profitable use of the money already spent on these two missiles.

Working on the basis of the Blue Streak/Black Knight combinations, Dr. Hilton of the Hawker Siddeley Astronautics section has projected a scheme for the placing of three satellites in an orbit inclined at 63 deg to the equator.

Satellite communication system should be used to supplement the existing cable system rather than replace it. At the same time, it would eliminate the need for the projected around - the - world cable which is estimated to cost about $250 million.

For optimum usefulness, satellite orbits would be timed to coincide with peak traffic loading. Most of the world's telephones are in the hemisphere including Europe and N. America. Due to the time difference between these two land masses, traffic is heaviest in the British afternoon. Taken generally around the Earth, the communication peaks follow the sun.

Because the satellite would be doing most useful work while it approaches and recedes from its apogee, the best arrangement would have the elliptic orbit pointing toward the sun. Inertia would main-



tain the ellipse in one direction only while the earth makes its annual circuit of the sun. Theoretically, the orbit would not maintain a direction towards the sun. However, the equatorial bulge perturbs orbits by rotating the orbit plane and axis. By judicious choice of orbit, it would be possible to use the perturbation to rotate the orbit once a year and maintain a direction towards the sun.

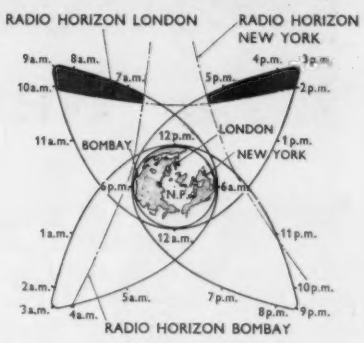
In an equatorial orbit with a perigee height of 300 mi the satellite would make 4.67 orbits a day if the exact annual perturbation is to be experienced. This corresponds to 14 orbits in 3 days and if 3 satellites were orbited at one-day intervals, a daily routine of having one in the area needed would result. The other two on their time off from N. America duty would give adequate coverage on the dark side of the Earth. It would also be possible to use them for a link over very long distances although they may be below the radio horizon. This could be done either from one satellite to the other or using a ground station at an intermediate point.

Some financial reward may be gained by leasing satellite capacity to countries that can make use of them during the dark hours.

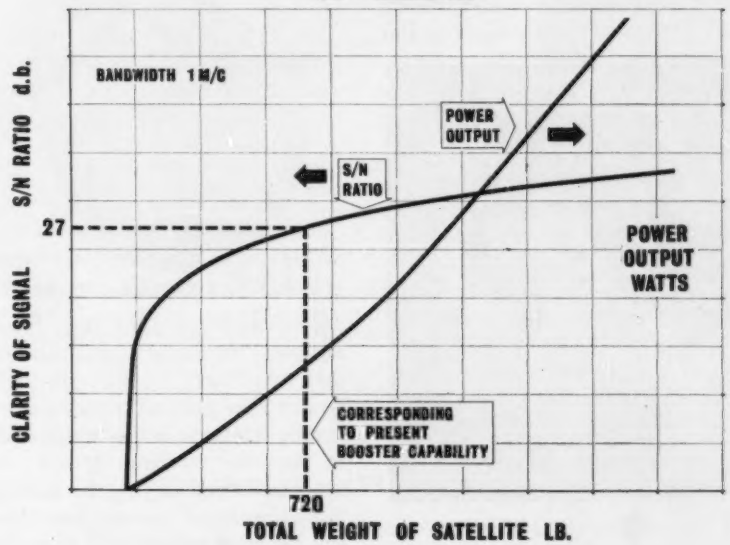
To make such a project worthwhile 100 telephone channels for both ingoing and outgoing calls would be necessary. A power of 1 watt per channel would be adequate, so a total of 200 watts of power would have to be available. Additional power would be needed for other uses on the satellite, and possibly as much as 500 watts would have to be provided by solar cells. These could be built into a reflector dish arrangement capable of giving a signal strength gain of 10 decibels.

To maintain the vehicle at a constant attitude relative to the Earth, infrared horizon seekers would be used. An electrically-driven flywheel unit could provide the necessary turning force to correct small deviations from alignment. Assuming that it were ultimately possible to develop equipment having a 20-year life, then satellite communication could allow trans-atlantic calls at one-twentieth of their present cost. A more limited life would have to be expected from the first generation of communication satellites, and it would be necessary to replace them periodically. Space activity of this nature would provide the nucleus of an industry which could grow progressively in the next decade, in preparation for the greater undertakings of the future. ✦

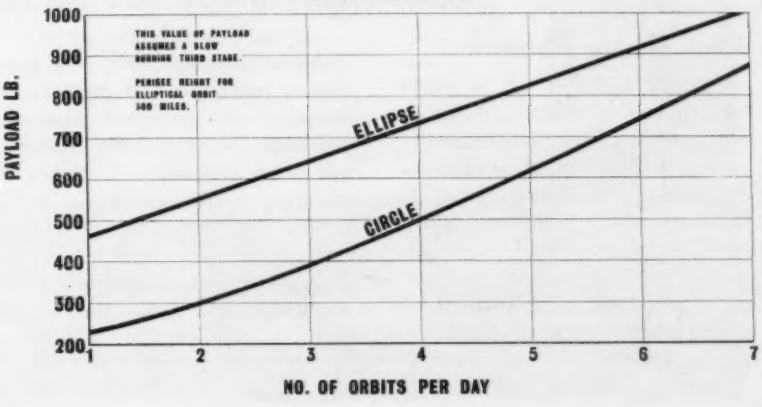
COMMUNICATION PERIODS; LONDON - NEW YORK; LONDON - BOMBAY WITH AN EQUATORIAL ORBIT



COMMUNICATION PERFORMANCE AS A FUNCTION OF WEIGHT



EFFECT OF ORBITAL PERIOD ON PAYLOAD POLAR ORBITS



New Materials

Plastic Chain Frame

"Chain Frame" plastic structure is made from filament wound sections. Pre-stressed member has exceptionally high strength to weight ratio. Structural frames and channels of different shapes can be designed to special requirements. Chain Frame concept employs resin-impregnated reinforcement filaments which are pre-stressed along predetermined patterns to give desired strength property. Certain portions

of the reinforcement filaments are given a longitudinal pattern. Others are designed into a "chain" pattern that interlocks the structure.—B. F. Goodrich Aviation Products.

Circle 50 on postcard for more data

Anti-Flame Phenolic

"Insurok T-777" is a paper-base, phenolic laminate. It has exceptional flame-retardant characteristics. Availability of copper-clad or non-clad types is immediate. The laminate rates as "self-extinguishing with zero inches burning distance." T-777 possesses good electrical properties, fine dimensional stability and punching qualities.—Richardson Co.

Circle 51 on postcard for more data

Cushion For Propellants

Fibrous glass materials molded into pads can provide a cushion for solid propellant combustion chambers. As the solid propellant grain expands in warm weather the material (VIBRA mat) absorbs the

expansion, keeping the grain intact and not permitting it to crack. As the propellant contracts in cold weather, the padding expands, eliminating looseness which would lead to vibration cracking. Spring rate is controlled by varying the density. Typical stiffness in a medium density produces a load of 25 psi at 50 per cent deflection.—Fibrous Glass Products Inc.

Circle 52 on postcard for more data

Polycarbonate Plastics

Lexan polycarbonate resin is a transparent thermoplastic with good impact resistance and dimensional stability. It has good electrical properties, resists staining, humidity and many chemicals. Currently in use in over 300 commercial applications, it is expected to be in increasing demand in aerospace industries. Electrical and electronic applications are major fields of expansion.—General Electric.

Circle 53 on postcard for more data

continued on page 74

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a flexible, dynamic approach to propulsion and ordnance

Amcel is an organization of specialists and special facilities, dedicated to second generation exploration and innovation in the fields of propellants, explosives, and related technologies. It is fully staffed and equipped for independent and contracted research and development programs, and pilot production.

Amcel facilities offer the efficiency of complete integration—a 1300-acre site that accommodates laboratories, static and flight test range, manufacturing and administration. This close departmental liaison helps to shorten lead time between concept and delivery.

Amcel is a subsidiary of Celanese Corporation of America. It is backed by the extensive research and production capabilities of this pioneer producer of organic chemicals, plastics and synthetic fibers.

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MODEL 850 Meets Mach 3 requirements of MIL-P-25757A (USAF).

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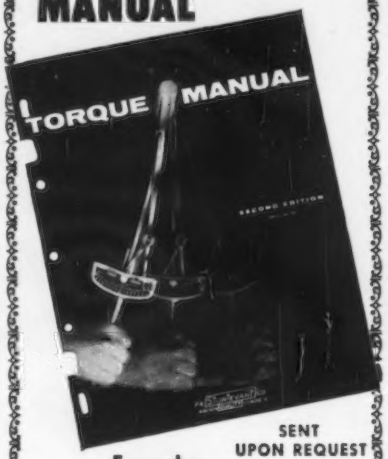
"TORQUE WRENCH" MANUAL



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Formulas
Applications
Engineering Data
Screw Torque Data
Adapter Problems
General Principles

P.A. STURTEVANT CO.
ADDISON QUALITY ILLINOIS

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What more do you want

GRAPHITE

to do for you ?

Graphite has been useful in aircraft and missile problem-solving as a component material in rocket motors, in brazing fixtures for airframe construction, and in other refractory applications.

Further and more advanced uses of graphite in space age progress may well be developing now as part of your design engineering program. We would welcome the opportunity of having our engineers, technicians and production personnel assist you in these developments.

For an introduction to the excellence of GLC graphite — and to one of the world's outstanding graphite producers — write for a free copy of our illustrated brochure, "Graphite For Diversified Industrial Applications".

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New Materials

...continued

Solid-Solution Alloy

Molybdenum - tungsten alloy powders, have been developed for production of true solid-solution alloy products. Alloy powders are produced by hydrogen reduction of the oxides or ammonium compounds of molybdenum and tungsten.

Two grade series, MA-28 and MA-39, are offered. Each grade will be supplied in three different percentage compositions, although any desired composition can be produced since molybdenum and tungsten form a continuous series of solid solutions.—Sylvania Electric Products.

Circle 54 on postcard for more data

For Faster Brazing

Silver brazing filler metal with a flux core allows faster and easier brazing. Designated Aircosil Fluxcor 45, the material assures the correct amount of flux for the size of the brazing alloy used. The alloy composition is available in approximately 70 to 80 oz. coils of 3/64 in. equivalent size. Equivalent size indicates the amount of silver alloy available in the composite, expresses as a solid wire. Shelf-life is good.—Air Reduction Co., Inc.

Circle 55 on postcard for more data

Lubricant For 750°F

Surf-Kote L-1020 is a new hi-temp, hi-pressure lubricant. It contains a modified molybdenum disulfide compound and other additives suspended in a synthetic based vehicle. The vehicle evaporates and leaves a durable dry film of solid lubricating compound on most metal surfaces, preventing friction problems up to 750°F. The lubricant can be applied directly to load-bearing surfaces or through grease cups and zerk fittings.—Hohman Plating & Mfg. Co.

Circle 56 on postcard for more data

Gold Recovery Unit

A process for recovering gold lost in electroplating is available. Until now, between 4 and 10 per cent of all gold used in electroplating has "gone down the drain," according to developer of process. The loss runs to millions of dollars a year.

The recovery system is called Gold Saver. It consists of:

- A column of special resin, small "BB" size particles, which capture gold in solution that now is being lost.
- A pump for circulating through the resin column the water in which the gold is dissolved. — Technic Inc.

Circle 58 on postcard for more data

Guidance Materials

Special hot-pressed infrared-transmitting optical materials can be used under the temperatures and stresses. One material has retained infrared transmittance for an hour at temperatures of 1800°F. Infrared transmittance of a number of the new materials is unaffected by long exposure to 1300°F.

Called Irtran, the optical materials can be selected to cover a wide range of infrared radiation and even radar waves. They are valuable for systems that use a target-hunting combination of radar and infrared.—Eastman Kodak Co.

Circle 59 on postcard for more data

Silicone-Resin Paper

An asbestos and silicone resin paper contains no organic binders. It is suitable for operation at Class C temperatures (over 180°C).

Electrical properties are not impaired by exposure to 275°C for 450 hrs. Although temperature limitations of this paper are determined by the resin used, the asbestos itself is satisfactory for applications requiring resistance to considerably higher temperatures.

The paper, Style #7601S, is available in gauges from 0.0025 to 0.0065 in. Based upon a gauge of 5.5 mile, the paper weighs 26 pounds per 100 square yards. The concentration of the silicone resin impregnation is approximately 60 per cent.—Raybestos-Manhattan.

Circle 57 on postcard for more data

Titanium Diboride

Titanium diboride shapes of higher strength, size, and purity are the result of a new manufacturing process. The process reduces the oxides of titanium and boron, and produces a very fine high-purity powder that is then fabricated into various shapes. Cylinders with 14 in. diam, 10 in. length, and weighing 260 lb. have been produced.

Titanium diboride resists oxidation at temperature as high as 1000°C, and has a relatively low oxidation rate even at 1400°C. The material has an elastic modulus of 60×10^6 from 25 through 2000°C. Its coefficient of thermal expansion is 2.5×10^{-6} cm/cm from 25 to 200°C and 8.1×10^{-6} cm/cm from 25 to 1300°C.—National Carbon Co.

Circle 60 on postcard for more data

Aidco 66

All purpose cleaner can remove and emulsify all types of aliphatic hydrocarbon oils and greases. In addition, germicidal ingredient controls bacteria and removes and prevents odor. Called Aidco 66, it is currently used by nuclear research and radiation laboratories in environmental-controlled areas which require critical cleanliness.—Alloy Industries Development Corp.

Circle 61 on postcard for more data

Brazing Compound

High temperature brazing compound withstands environments up to 1800°C. This new alloy is particularly suitable for joining porous, refractory metals, such as tungsten, molybdenum, or tantalum, to solid materials without infiltration of the permeable material. Future uses: high temperature joints in refractory materials, thermionic converters, electronic components. —Electro-optical Systems Inc.

Circle 62 on postcard for more data

Corrugated Core

Trussgrid is a honeycomb core designed to expand uses of sandwich panel construction.

Fabricated of aluminum alloy 5052, Trussgrid makes use of cross-laminated layers of corrugated foil. Corrugations of each layer form a 90 deg angle with those of its neighbor. Thus channels in alternate layers of foil run in the same direction, providing strength and rigidity in three planes.—General Grid Corp.

Circle 63 on postcard for more data

New Epoxies

Epoxidized polyolefin resins called Oxiron are now available in drum quantities. Resins were introduced early in year. They differ from conventional epoxies in molecular structure, reactivity, and end properties, and are being examined for new applications in the fields of laminates, castings, adhesives, and surface coatings. Their properties and economies give promise of penetration of a number of major application areas not previously open to epoxy resins.—Food Machinery & Chemical Corp.

Circle 64 on postcard for more data

Electrical Insulator

Epoxy glass insulating material called "Irvington No. 2525" retains high dielectric strength and flexibility under continuous Class F temperatures. The material is compatible with all Class F magnet wires, "Scotchcast" electrical resins and most other epoxy systems.

It is flexible, confirms snugly on application and does not discolor after heat aging.

Availability: slit tapes, sheets or full 36-in. widths in thicknesses of 0.003, 0.007, and 0.010 in.—Minnesota Mining & Mfg. Co.

Circle 65 on postcard for more data

continued on next page

SILICONE NEWS from Dow Corning

By Jupiter... it's reliable!

Reliable . . . that one word sums up the record established by the Army's Jupiter and the performance of Silastic®, the Dow Corning silicone rubber is part of that record.

Rubber ducts must not crack even though frozen hard and brittle by liquid nitrogen. Access door seals must remain a rubbery seal despite high skin temperatures. Rubber parts must be "ready-to-go" even after long storage without signs of aging cracks. Chrysler Missile Division engineers specified Silastic to help keep the Jupiter ready . . . Silastic, flexible from —130 to 500 F and ageless in storage.

Photo courtesy Chrysler Missiles Division

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FROM -300°F TO 4000° PLUS
The world's finest thermocouples. New process increases precision and temperature range. Exceeds all military and commercial specs. Con-O-Pak is used in aircraft, missiles, nucleonics, chemical processing. Useful data? . . . Ask for "The Con-O-Pak Story."
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Circle 29 on Inquiry Card

New Materials

. . . continued

Graphite Felts

Non-woven forms of flexible graphite and carbon are produced by the same process as graphite cloth. The diameter of the filaments in these products is about 0.003 inch. Insulation, gas filtration, and gasketing are some of the expected uses of these new, high-temperature, flexible materials. Oxidation in air is not a problem up to 650-700°F. In neutral and reducing atmospheres, all these felts can be used at temperatures up to about 5000°F. —National Carbon Co.

Circle 66 on postcard for more data

Glass Fiber

A glass fiber possessing approximately 50 per cent greater rigidity with no sacrifice in strength has been developed for the Air Force.

Known as "High Modulus Glass," the new fiber will permit important weight savings in the development of aerospace vehicles and missiles through its use as a reinforcement in structural plastic laminates. — Owens-Corning Fiberglas Corp.

Circle 67 on postcard for more data

Stable Epoxy

Unox epoxides, with cyloaliphatic structures, eliminate the light-unstable phenolic groups found in conventional epoxies based on epichlorhydrin and bisphenol A. Unox 201 is the most versatile of the new family of diepoxides. It can be formulated to give a wide range of high temperature properties, toughness, cure speeds, and handling characteristics. Its properties point to end uses in electrical and electronic components and encapsulation, tooling coatings, laminates, adhesives, and cross-linking applications.—Union Carbide Chemical Co.

Circle 68 on postcard for more data

Stripping Agent

Epoxy and polyester-based coatings are easily removed with a new gelatinous self-activating stripping agent. This adheres to all surfaces —contoured or vertical. It is particularly useful for removing commercial paints, or resin-based coatings and materials from large-area surfaces. It will not corrode, discolor, or damage copper, aluminum, or ferrous metals.—Narmco Materials Div., Narmco Industries.

Circle 69 on postcard for more data

Stops Engine Fires

Bromochlorodifluoromethane is a liquid useful as a fire extinguisher. It is particularly effective against fire in aircraft engine or fires resulting from escaping lubricants or hydraulic fluid. The substance is a methane compound (CH_4) in which bromine is substitute for one of the hydrogen atoms, chlorine for another, and fluorine for the remaining two.

Carbon tetrachloride is a close relation. The methane compound isn't nearly as poisonous as its cousin, however. It is about twice as heavy as water. Because of its low boiling point, 27.5°F, it must be kept under pressure.—Firestone Tire & Rubber Co.

Circle 70 on postcard for more data

Semiconductor Stock

Clad-metal raw materials and stampings for semiconductors are now offered. They consist of an overlay of a low-melting point solder such as tin, tin-antimony or lead-tin-antimony clad on one or both sides of a base material such as 'A' Nickel, Nickel-iron, Kover, copper, gold or silver. Raw materials can be supplied in 2 in. max widths, with a minimum overall thickness of 0.001 in. Thickness tolerance can be held as close as plus or mininum 0.002 in. Stampings using this new raw material can also be supplied. — Accurate Specialties Co.

Circle 71 on postcard for more data

Epoxy Film Adhesive

New high strength supported epoxy resin film adhesive is called AF-106. It claims design and cost-saving advantages for the economical bonding of metal and paper honeycomb cores to metal facings in sandwich construction.

The adhesive provides metal-to-metal bonds, with shear strengths of over 2000 psi at 75°F, maintains high strength over a service temperature range of minus 67°F to plus 300°F and has good peel strength. It has high creep resistance under constant stress and resists water, 20 per cent salt spray, hydraulic oil and aromatic fuel.—Minnesota Mining and Mfg. Co.

Circle 72 on postcard for more data

Lubricant For 2200°F

Phosphatherm RN is a metal-forming lubricant. It is intended for use at temperatures between 1100 and 2200°F. The lubricant prevents galling, scoring and metal pickup when forming most types of common steels, steel and copper alloys and the exotic metals at elevated temperature. It is an eutectoid, a gradually-softening mixture of certain phosphates and other salts. On surfaces of 400°F, it forms an adherent, spreading, melt having excellent lubricity on both forming tools and materials being formed, especially alloy steels.—Alpha-Molykote Corp.

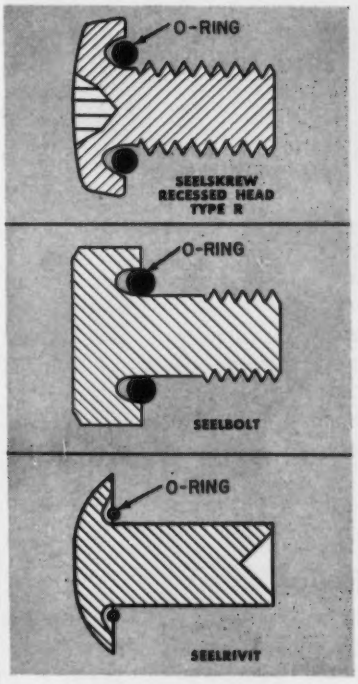
Circle 73 on postcard for more data

Anti-Rust Powder

Rusting can be prevented in storage without dismantling metal parts. Protection is provided by a slow vaporization of an Anti-Rust Powder. Powder is applied with squeeze-bottle through any convenient opening to a part's interior —for example, the spark plug port in an engine. Plug is removed. Powder is puffed in. Plug is replaced.—Westmore Inc.

Circle 74 on postcard for more data

SEELSKREWS*
SEELBOLTS*
SEELRIVITS*
High Pressure Self-Sealing
FASTENERS



- Removable and static self-sealing screws, bolts and rivets.
- These industrial fasteners meet all applicable military specifications.

SEND FOR CATALOG 359-A-27
describing items above, also seals for switches, shafts, circuit breakers, indicator lights and other electronic components.
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Designers and Manufacturers of
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Circle 30 on Inquiry Card

New Parts and Components

Cooling Units

Compact, lightweight, airborne cooling units, like that produced for the Eagle missile, are being developed for other than airborne application. The Eagle missile cooling unit is designed for cooling the

missile's guidance system Klystron amplifiers. This small unit has a nominal heat dissipation rate of 9375 watts. Other airborne liquid-to-air heat transfer systems, which are being developed for GSE applications, have cooling capacities of from 100 to 10,000 watts with operating temperatures in the —65° to 250° range.—Lear Inc.

Circle 75 on postcard for more data

Relief Valves

Two newly developed valves are constructed to control pressures generated by hot propellant gases.

Seal V-4000 uses a gas reference pressure for relief pressure control. This unique design feature permits ready adjustment of relief setting from a remote source—particularly useful feature in test cell applications. Relief pressure capabilities range from 10 to 1500 psi with temperatures to 2200°F. Seal V-4001 is recommended for operational rocket - missile applications. The valve features an external spring which permits rapid dissipation of heat to eliminate cracking pressure variation.—Microporous Filter Div., Circle Seal Development Corp.

Circle 76 on postcard for more data

Battery Incorporates Internal Heating

Silver-zinc battery is the first of its type to incorporate successfully an internal chemical heating device.

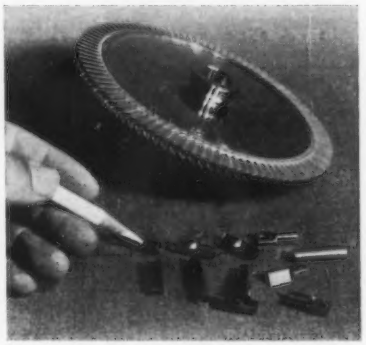
Chemical heating makes it possible to increase the reliability and effectiveness of some weapons and missiles because, for the first time, battery power can be used in them. The chemically-heated ESB primary unit delivers an average of 10 to 12½ watt-hr per lb, including heating device.

Capable of quick power delivery in ambient temperatures as low as minus 65°F, the battery is heated when electrical matches automatically ignite chemical powder to warm the electrolyte.—Missile Battery Div., The Electric Storage Battery Co.

Circle 77 on postcard for more data

B-70 Turbine Wheel

Sheet metal turbine buckets reportedly cut costs and weight of small turbine wheels by more than

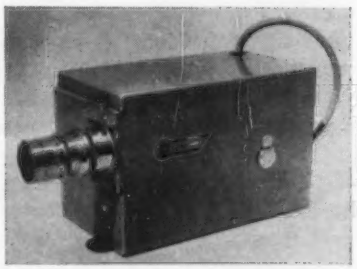


50 per cent. They are used in two new highly-advanced turbine-powered fuel pumps. The pumps go into the J93-3 jet engine, scheduled to power the North American B-70. —General Electric.

Circle 78 on postcard for more data

Films X-15 Flights

Two of the smallest cameras ever designed for extreme high performance film X-15 stress changes and wing surface movements. Mounted on each side within the fuselage and actuated by a cockpit switch, cameras photograph through a tiny porthole recording on 16mm film. Pulse-cine device takes a predetermined number of frames per second to record the minutest



changes. Cameras are only seven inches long by four inches wide and weigh eight lb apiece.

Future use: a wide variety of aircraft, satellite, rocket and missile applications.—Vought Camera Co.

Circle 79 on postcard for more data

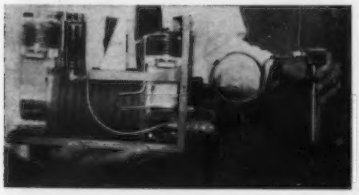
1200°F Bolting

New bolt series, designated EWB 1218, has 39 per cent greater tensile strength and 54 per cent higher stress rupture strength than current elevated temperature bolting used in the 900-1200°F application range. The bolts are intended for applications where standard 1200-degree bolting made of A-286 alloy is currently used. They are made by special processing techniques from U-212 material, an iron-base alloy similar to A-286 with additional alloying for improved properties.—Standard Pressed Steel Co.

Circle 80 on postcard for more data

Cryogenic System

Miniature cryogenic electronic cooling system uses nitrogen to provide one watt of refrigeration at 80°K.



Unit consists of a compressor with an absorber filter, and a remote refrigerating element that is connected to the compressor by flexible lines. Both a 400 cycle, 208 volt, 3 phase unit for airborne use and a 60 cycle, 115 volt, single phase unit are available. This self contained system weighs 16 lb.—Air Products Inc.

Circle 81 on postcard for more data

Fluid Reservoir

New series of self-pressurizing hydraulic fluid reservoirs are in the form of airless containers operated

by system pressure. Airless system feature offers freedom from foaming and fluid oxidation, while providing positive pump supercharge pressure, regardless of the attitude of the missile or space vehicle.—Vickers Inc.

Circle 82 on postcard for more data

Filaments and Boats

New complete line of tungsten, tantalum and molybdenum filaments and boats are now available. All parts are stress-relieved to obtain the longest possible life in operation, and to maintain their geometry during use. Primary uses for these filaments and boats include: electronic component processing, coating of optics, plastics and toy decorative coating, precision instrumentation manufacturing, vacuum metalizing in basic research laboratories.—Electronics Div., Allen-Jones Inc.

Circle 83 on postcard for more data

Aluminum Connectors

Aircraft cable connectors are of high purity aluminum with cold-forged construction. They have a long gripping area that holes the

conductor to 95% of its rated strength, and electro tin-plated surfaces throughout. Connectors have withstood tests of up to 100 hours in salt fog atmosphere.—The Thomas & Betts Co.

Circle 84 on postcard for more data

Heat Radiator

Heat radiator for earth satellite and interplanetary space vehicles has been demonstrated publicly.

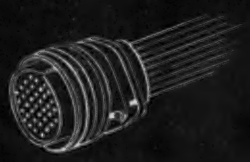
Device, designed to overcome the problem of getting rid of waste heat which will be generated in nuclear-powered space vehicles, is known as a moving belt radiator. It is lighter by two-thirds than conventional tube and fin radiators.

Twin belts extend in from the waste heat rejection core, move continually, picking up the heat from the outer surface of the core and radiating it from the surfaces of the belts as they rotate in space. At launch the belt would be wrapped around the generating assembly and enclosed in a disposable aerodynamic shield.—Rocketdyne.

Circle 85 on postcard for more data

continued on next page

BENDIX
MS-R
ENVIRONMENT RESISTANT
Connectors



Bendix MS-R series are the small, lightweight, more efficient and compatible environment resisting class of connectors as specified in the latest version of MIL-C-5015.

Main joint and moisture barriers at solder weld ends have integral "O" rings. Grommet design of "slippery rubber" is sealing medium for individual wires. This provides easier wire threading and friction-free travel of grommet over wires.

Many other features are described in MS-R Bulletin. Send for your copy today, or

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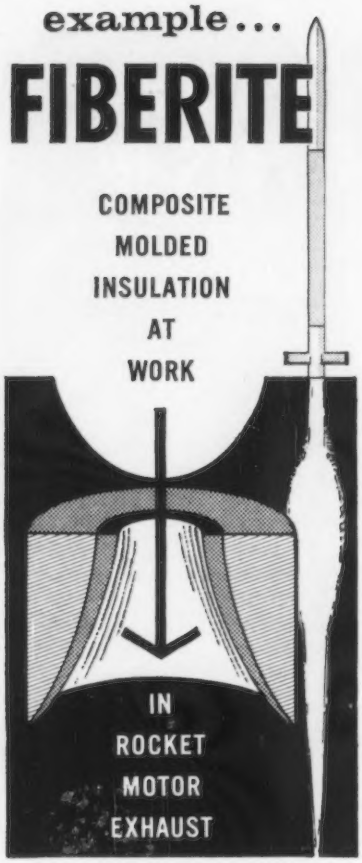
AVNET•4180 Kettering Blvd., Dayton 39, Ohio-AX 8-1458
AVNET•2728 N. Mannheim Rd., Melrose Park, Ill.-GL5-8160
AVNET•1262 N. Lawrence Sta. Rd., Sunnyvale, Cal.-RE6-0300

Circle 31 on Inquiry Card

example...

FIBERITE

COMPOSITE MOLDED INSULATION AT WORK



Minimum erosion and ablation resistance are needed in exit areas to resist over 5000° F. and high velocities. Excellent results were achieved with Fiberite MX 2630 and MX 2630A. The mechanical strength and thermal insulation were provided by Fiberite MX 2625 with 2630 giving the ablation resistance. By molding these two formulations into a composite structure a superior insulation was developed.

Fiberite compression molded high temperature insulating materials are designed for MIL-M-19536 applications: chopped fiber impregnated phenolic with special reinforcement materials, i.e., fiberglass, graphite cloth, ceramic and quartz. Fiberite insulation is specified in the Lar, Bull Pup, Polaris, Minute Man, Nike Zeus, Red Eye and many others.

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Missile engineers will find our research helpful in solving problems requiring materials for special performance. Write factory for bulletin "Fiberite High Temperature Insulating Materials."

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MOLDING COMPOUNDS

Circle 32 on Inquiry Card

New Parts and Components

. . . *continued*

Pressure Transducers

Two new pressure transducers feature precycled, preestablished, standardized operation in temperature environments ranging from

—100°F to +600°F. They operate in these temperatures during shocks exceeding 100g for 11 milliseconds in any direction.—Electro-Mechanical Research Inc.

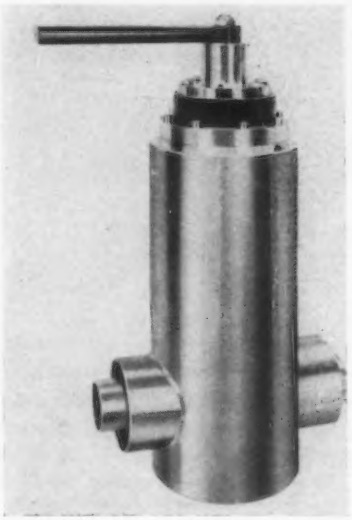
Circle 86 on postcard for more data

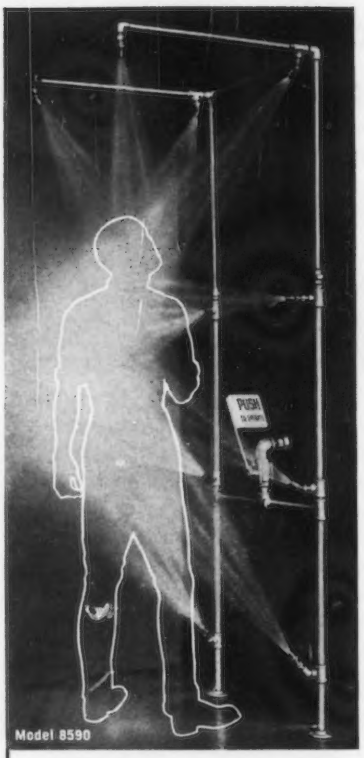
Ball Valves

Liquid hydrogen ball valves with unusually low cool-down weight are for use in rocket engine development.

Ranging in size from ⅜ to 8 inch diameters, the valves are encased in welded stainless steel vacuum jackets to insulate the valve body from the surrounding air. This minimizes heat transfer from the surrounding air, eliminating liquid hydrogen boil - off. — Hydromatics Inc.

Circle 87 on postcard for more data





contaminants off FAST!

HAWS SAFETY SHOWERS send torrents of rushing water from all angles – washing away dangerous irritants in a hurry!

Slap open the conspicuous "Push to Operate" valve. Hard-running streams from 10 *adjustable* nozzles drench victims in seconds.

You can depend on HAWS for the instant, *positive* first aid so vital until medical help arrives.

This "Safety on tap" can mean the difference between temporary irritation and permanent injury. Get the facts! Write for HAWS new safety catalog. Do it today!

Valve shown three-quarters open.

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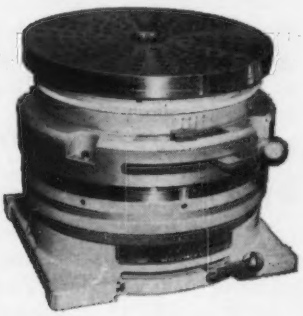
Export Dept. 19 Columbus Avenue San Francisco 11, California, U.S.A.

Circle 33 on Inquiry Card

ACCURATE
ANGULAR INDEXING to
1/4 SECOND OF ARC with
©MILICHEX

ROTARY INDEXING TABLES

Designed to provide indexing accuracies of ¼ second of arc, Milichex tables are available in many models and combinations to fit almost any need, including angular indexing to minutes and seconds. (1,296,000 positive settings within a full circle.) "Laboratory" accuracy to within 12-millionths of an inch at a 20 inch diameter is possible.



This Model M2X-900 Milichex allows quick setting to any full or fractional angle in ¼ degree increments on a production basis. Operator merely sets tables to two marks. They automatically lock into correct setting.

All Milichex models are flat and parallel within 0.000050 inches and provided with numerous threaded holes for easy mounting of workpiece or fixtures. Milichex tables can be used also for checking roundness or concentricity within 10-millionths.

For details write for Bulletin X-60

MICHIGAN TOOL CO.
7171 E. McNICHOLS ROAD
DETROIT 12, MICHIGAN

Circle 34 on Inquiry Card

Low Pass Filters

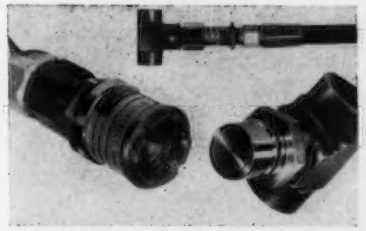
Miniaturized coaxial low pass filters are obtainable from 125 to 4000MC. They feature low insertion loss and VSWR in the pass band and more than adequate rejection in the stop band.

This new design permits construction of low frequency filters which are extremely compact, a 125m cut-off filter with type BNC connectors is only 5.8 inches long and weighs 2.8 ounces.—Maury & Assoc.

Circle 88 on postcard for more data

Fluid Coupling

Quick-disconnect fluid coupling has self-sealing features. This assures zero leakage and no air inclusion or other contamination during connect-disconnect. The new



disconnect features positive, push-pull lock that may be operated with one hand or with remote control mechanical or electromechanical devices. After disconnect, no seals are exposed, and the coupling valve maintains full pressure of 4000 psi. —Symetrics Inc.

Circle 89 on postcard for more data

New Filter Cuts Decontamination Costs

Electronic oil filter is designed to meet the exacting requirements of advanced missile systems. It is designed for use in decontaminating hydraulic test stands, aircraft hydraulic systems, missile and rocket systems and transformer oils.

Field tests have gone on for more than a year. Filter is used in the Polaris program. Manufacturer claims it can cut contamination control costs by as much as 75 per cent.—Permanent Filter Corp.

Circle 90 on postcard for more data

continued on next page

MILLS-WOLF
STEEL
AEROSPACE AND GSE REQUIREMENTS

- T-1, ALL GRADES
- HY-80, 90
- MIL-S STEELS
- QQS SPECS.
- HIGH STRENGTH
- ALLOY STEELS
- DRILL ROD
- FORGINGS
- FABRICATION
- CASTINGS

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BUFFALO	ENTERPRISE 9885
CHICAGO	ENTERPRISE 9885
MILWAUKEE	ENTERPRISE 5140
LOS ANGELES	ZENITH 9-9885
OAKLAND	ENTERPRISE 1-5140
SAN FRANCISCO	ENTERPRISE 1-5140

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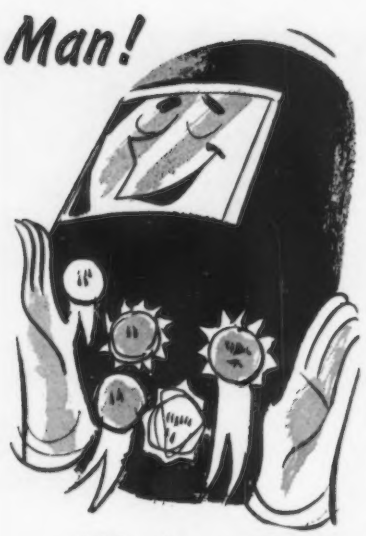
Circle 35 on Inquiry Card



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AMAZING BRAZING
Circle 36 on Inquiry Card

New Parts and Components

. . . *continued*

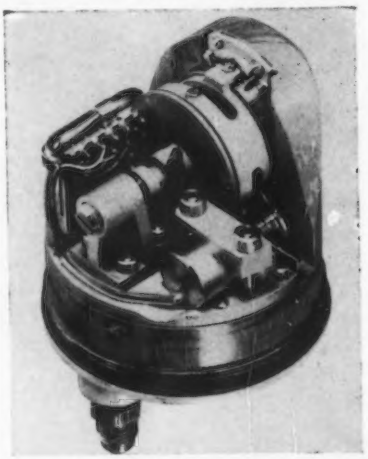
New Fuel System

Fuel injection system is for reciprocating aircraft engines up to 600 hp. It consists of a unit that accurately measures air flow to the engine, a servo-operated fuel proportioner, a mixture control, and a servo-operated discharge distributor. It can be used for either intake valve port or single point impeller injection.—Bendix Products Div.

Circle 91 on postcard for more data

Altitude Control

Altitude control transducer provides potentiometric output which is linear with either pressure or altitude for use in autopilot systems, fire control systems, and drone guidance systems.—Giannini Controls Corp.



Circle 92 on postcard for more data

Thimble-Size Bellows

Sensitive bellows is for use in a force balance or closed-loop pressure transducer. The miniature bellows is being used in pressure transducers for flight control systems designed and built by Autonetics Armament and Flight Control Product Division for the USAF GAM-77 (Hound Dog) air-to-surface missile. It is about the size of a thimble.—Metal Bellows Corp.

Circle 93 on postcard for more data

No Moving Parts In Power Unit

Transistorized electrical unit supplies power for electronic circuits in missiles.

The unit, an inverter which converts DC power to AC power, has no moving parts—a feature that provides greater missile reliability. It is about half the size of other types.—The Bendix Corp.

Circle 94 on postcard for more data

Rubber Coupling

Flexible rubber coupling for airplane fuel lines weighs significantly less than metallic couplings. They are reinforced internally with multiple fabric plies and withstand negative pressures as high as 10 inches of mercury without collapsing. Every coupling is tested to a proof pressure of 240 psig. Each is designed to withstand burst pressures up to 480 psig.—B. F. Goodrich Aviation Products Co.

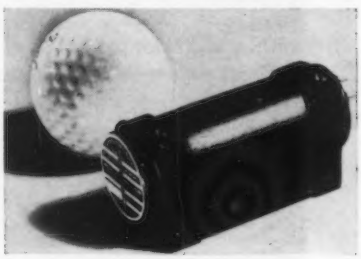
Circle 95 on postcard for more data

Gyro Improves Damping

Sub-miniature rate gyro holds damping from 0.5 to 0.9 times critical over a temperature range of −54°C to +84°C. Response time remains uniform over the environmental temperature range. A uniformly low natural frequency oscillation of the gimbal over a wide temperature range assures fast gyro recovery even during rapid-sequence maneuvering.

Maximum power consumption for the spin motor is 1½ watts total. Weight: 6½ oz.—Instrument Div., Lear Inc.

Circle 96 on postcard for more data



New Electronic Products

Dynamic Test-Set

New 200 amp dynamic test set, Model 164, simultaneously evaluates characteristics of four silicon rectifiers in a full wave circuit.

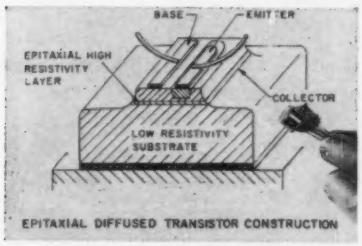
Basic circuitry consists of two power supplies—a low voltage, high current supply for forward characteristics; and a high voltage, low current supply for reverse characteristics.

Test capacity of the Model 164 is four rectifiers in the range of 5-200 amp DC average forward current. Peak reverse voltage is adjustable between 0-1500 v.—Wallston Associates.

Circle 97 on postcard for more data

Epitaxial Transistors

New "epitaxial" germanium mesa transistors consists of thin semi-conductor layers deposited on low resistivity substrates of germanium. Performance is reportedly



EPITAXIAL DIFFUSED TRANSISTOR CONSTRUCTION

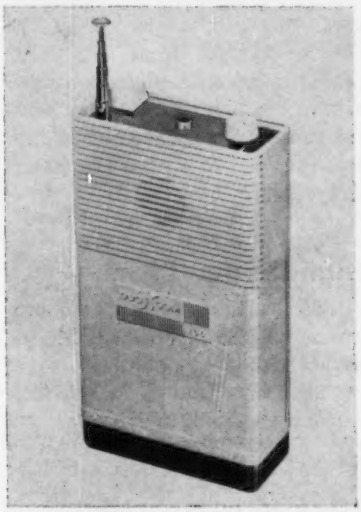
superior to conventional germanium mesa transistors.

Designated Types SYL2300 and SYL2301, the new devices, available in production quantities are electrically similar to conventional mesa transistor Types 2N702 and 2N711, with improved performance in saturation voltage and switching time.—Sylvania Electric Products Inc.

Circle 98 on postcard for more data

Two-Way Radio Weighs 20 Oz.

Portable two-way radio has many applications for ground support operations where short range communications are required. Called



the DUO-COM 100, this "pocket-size" radio weighs only 20 oz. It is powered by eight miniature penlight cells, which affords 40 hr of continuous use at a cost of less than 2 cents per hr. Range is five miles. The 10 transistor circuit provides a compact unit measuring 1⅝ x 4 x 7¾ inches.—Osborne Electronic Sales Corp.

Circle 99 on postcard for more data

Intercom TV

High-resolution-type television camera has the option of built-in sound channel for crisp voice communication. The more important circuit features of this medium-priced camera are: Low-noise Cascode video input, 8 mc video bandwidth amplifiers with 600-line horiz. resolution, linear phase type aperture correction.—Tele-Tronics Corp.

Circle 100 on postcard for more data

Process Regulator

New Electronic Process Regulator can be used as a flow regulator, a precision valve positioner, or a temperature control.

Photograph shows a pressure regulator which can control pressure either immediately upstream or downstream of the valve. The pressure may also be controlled at remote points in the flow system. Three models cover the range from 30″ HG vacuum to 5,000 psig.

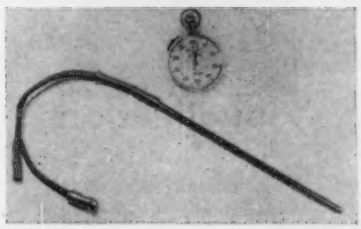
A single unit can operate at low or high pressures and produce accuracies of pressure regulation previously unavailable to designers. —Physics For Industry Inc.

Circle 101 on postcard for more data

Thermocouples Have Quick Response

Two ultra-fast response thermocouples have millisecond response time. They are available in either single shielded or unshielded configurations.

The 479-C shielded thermocouple has demonstrated a capability of 100 millisecond response,



measured at 63 per cent of temperature change from 32°F to 190°F. The 452V spot welded unshielded thermocouple is capable of even faster response, measuring 35 milliseconds under the same conditions.

Thermocouple material is 20 gauge chromel - alumel. — Press-Temp Products Div., Propulsion Development Laboratories Inc.

Circle 102 on postcard for more data

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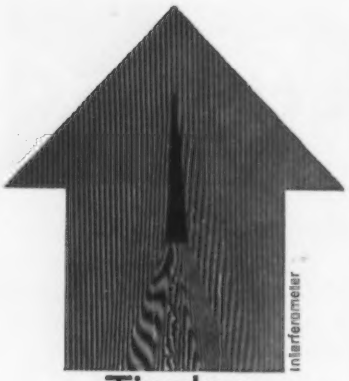
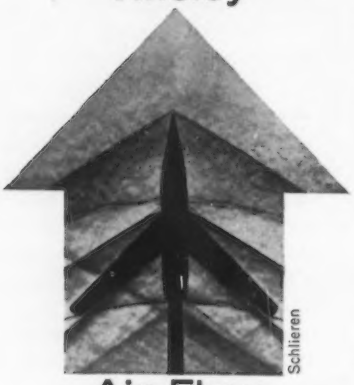


Tinsley



Air Flow

Visualization

From design to construction to installation, Tinsley will develop a complete optical mechanical system to meet your performance requirements for visualization in wind tunnels, arc tunnels, shock tubes, plasma jets. Among our clients: Douglas, Lockheed, NASA, North American, Rocketdyne, Republic. For literature write Air Flow Dept. TINSLEY LABORATORIES, INC., 2526 Grove Street, Berkeley 4, Calif.

Circle 37 on Inquiry Card

New Electronic Products

. . . *continued*

Photoelectric Control

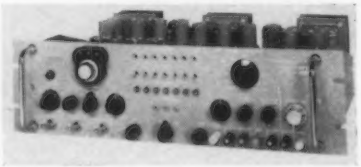
Transistorized Photoelectric Controller PE-601 is a unique approach to design of photoelectric controls. The PE-601 consists of a transistor amplifier and a power supply packaged in a plug-in unit measuring 2 in. x 2 in. x 2 in. The system operates from 115 VAC 50/60 cycles with power consumption of less than 3 watts total. Sensing range from portions of an inch to eight feet.—Syracuse Electronics Corp.

Circle 103 on postcard for more data

Signal Simulator

Electronic signal simulator produces precise PAM, PDM, or PAM/NRZ pulse trains.

Significant features include continuously variable pulse rate from



20 to 7000 pulses per second, programmable signal levels, zero and full-scale pulses anywhere within the frames, and provision for application of noise to the pedestal and information levels of the wave train.—Telemetrics Inc.

Circle 104 on postcard for more data

Potentiometers

Potentiometers featuring a torque of 0.003 oz-in. to 0.025 oz-in are now available. They accurately divide an electric current or voltage in proportion to shaft rotation up to 354°, and can be furnished with linear and sin-cos functions. Useful angles up to 360° in a toroid form can be provided. Potentiometers withstand vibration at 10 g to 1000 cps.—Giannini Controls Corp.

Circle 105 on postcard for more data

Micro-Miniature Transmitter

Transmitting system is small enough to be packaged in an aviation flight helmet. It can transmit over great distances physiological reactions of pilot or astronaut.

The developed model consists of three low level amplifiers, three subcarrier oscillators, and a crystal-controlled transmitter. It can be adapted, however, for the addition of three or even six additional channels, equivalent to three or six additional measurements.—Vector Manufacturing Co.

Circle 106 on postcard for more data

Frequency Source

This 60-cps frequency source drives the capstan motor of an Ampex data-processing tape recorder. The Ampex AR-200 can withstand shock up to 15 g's, operate at altitudes up to 100,000 feet, function at temperatures anywhere between that of boiling water and −55C.

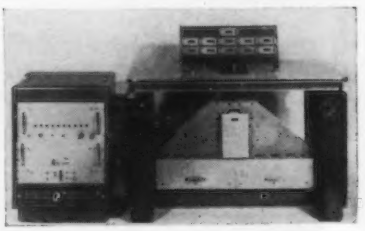
The heart of the unit, Hill FS17900, is a 3.84-kc, high-precision quartz crystal. The 60-cps output frequency is obtained by means of six binary frequency dividers.—Hill Electronics Inc.

Circle 107 on postcard for more data

Diode Tester

Model T-401A Automatic Diode Tester will automatically index, test, and sort diodes at the rate of 3600 per hour; will reject "shorted" or "open" units at the rate of 7200 per hour; and idles with open contacts at the rate of 2400 steps per hour. Test circuitry automatically corrects for diode orientation prior to testing.—Atlantis Electronics Corp.

Circle 108 on postcard for more data



Hi-Temp Transistor

First transistor capable of operating above 650°F has been developed. It is made from silicon carbide crystals about .002 inch thick. Researchers foresee its upper operating temperature at more than 925°.

The new device is a unipolar transistor which differs in operating principle from the bipolar type usually made from germanium and silicon.—Westinghouse Electric Corp.

Circle 109 on postcard for more data

Rotary Trimmer

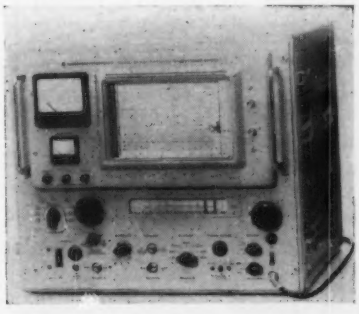
Miniature single turn rotary trimmer, is available with bushing or servo mounting, and is capable of withstanding in excess of 150 G shock and 15 G vibration.

Power rating of the unit is 2 watts at 60°C. Standard resistance is 10 ohms to 20 K.—International Resistance Co.

Circle 110 on postcard for more data

Spectrograph

Audio-frequency spectrograph has automatic sweep and extreme selectivity in both narrow and broad band operations. At 20 kc, measurements of the hum modulation sidebands can be made with the full resolving power of the set. Inherent



distortion of the set is low, permitting measurements even on low-distortion passive and active networks. Measured values are plotted by the recorder equipped with an automatic frequency sweep. — Rohde & Schwarz Sales Co.

Circle 111 on postcard for more data

continued on next page

Important facts to know about laminated plastics

A few Taylor composite laminates (left to right): copper-clad section; sandwiched copper component; Taylorite vulcanized fibre-clad part; laminated tube, copper inserts.

Composite Laminates Open Up New Design Opportunities

While the great variety of commercially available laminated plastics satisfy most electrical and mechanical requirements, there are applications that can benefit from the combination of properties provided by composite laminates. Recent advances in bonding techniques have made it possible to bond virtually any compatible material with a laminate. These can be supplied as clad or as sandwiched materials. And they can be molded into many shapes to fit design requirements. Taylor is presently supplying to order the following composite laminates:

- **Copper and laminated plastics.** Clad for printed circuits and formed shapes. Sandwiched for special applications.
- **Taylorite® vulcanized fibre-clad laminates.** These combine the high strength of laminated plastics with the superior hot-arc-resistance of vulcanized fibre. They are being used in both high and low-voltage switchgear applications. Also in applications where the high impact strength of vulcanized fibre may be advantageous.
- **Rubber-clad laminates.** Almost any type of natural or synthetic rubber may be used as the cladding material. These laminates are widely used for condenser tops in wet condensers to protect the laminate against highly alkaline electrolytes. They also have application in any part where sealing or chemical resistance is needed.
- **Asbestos-clad laminates.** For applications where high heat- and arc-resistance are required.
- **Laminate-clad lead.** Lead sheets sandwiched between Grade XX paper-base laminates have been used for X-ray shields. The laminate provides strength and contributes to the high shielding properties of the lead.
- **Aluminum-clad laminates.** These have been used extensively for engraving stock. They also offer possibilities as printed-circuit material and as plate holders for X-ray machines.
- **Beryllium copper-clad laminates.** Beryllium copper is nonmagnetic and a good conductor—properties that give these laminates possibilities in many applications.
- **Stainless steel-clad laminates.** Applications where nonmagnetic properties are required. Also in certain corrosive environments where the resistance of stainless steel to attack is an asset.
- **Magnesium-clad laminates.** These laminates have been produced in 108-in.-long sheets for use as screens for X-ray operators. Weight was a factor.

Our design and production engineers are constantly developing new materials, new applications, and new procedures for fabricating laminated plastics. Our experience is yours for the asking. And if you have a problem requiring assistance or more information on composite laminates, write us. Also ask for your copy of Taylor's new guide to simplified selection of laminated plastics. Taylor Fibre Co., Norristown 50, Pa.

Taylor
LAMINATED PLASTICS VULCANIZED FIBRE

NEW! from the TURCO Technical Film Library

FREE SHOWING!

Full Color TRAINING MOVIE

"HOW TO LOCATE FLAWS WITH DYE PENETRANTS"

Seen and Acclaimed by over 5000 Maintenance, Production and Quality Control Engineers!

Accurately — Simply Economically!

IN YOUR PLANT or location of your choice!

Now, your plant or technical group can learn the full story of flaw location with dye penetrants. See how dye penetrants provide greater inspection accuracy and speed at lowered cost for hundreds of industrial concerns whose inspection facilities range from huge multi-tank installations down to small $35 inspection kits. Witness *actual* dye penetrant inspections, *right in your own plant* or other location of your choice...all without any cost or obligation!

Produced by the Technical Film Staff of Turco, manufacturer of the Dy-Chek® inspection process, this 23-minute film visually demonstrates *every* aspect of dye penetrant inspecting from laboratory theory to authentic production-line techniques actually filmed on the spot during mass production inspections.

If your plant or technical group is interested, write today without cost or obligation for the Turco "Film Kit" described below.

SEE: Production-line inspecting of aircraft wing spars!

SEE: In-lathe inspections without disturbing set-up!

SEE: Location of weld porosity in pressure vessels!

SEE: Mass production inspection of small parts!

SEE: Location of fractures in wheels and gears!

SEE: Detection of heat cracks in brake plates!

SEE: a "flaw's-eye" view of how dye penetrants really work through glass!

Rush Coupon for FREE "Film Kit" No Obligation!

1 "SNEAK PREVIEW" – 4-page folder previews film in detail. Developed from producer's original "script." Leads you through each scene...start to finish. Shows how easily you can obtain film – no cost or obligation.

2 "INSIDE DYE PENETRANTS" – 8-page folder frankly reveals what dye pentrants are and what they are not! Illustrates many successful case histories of dye pentrant use in industry today.

3 "How to perform DYE PENETRANT Inspections" – 4-page technical folder details every aspect of dye penetrant inspections from precleaning to interpreting results. Contains valuable "Dwell Time Chart."

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FACTORIES: Chicago, Houston, Los Angeles, London, Rotterdam, Sydney, Mexico City, Paris, Hamburg, Montreal, Manila, Naha (Okinawa)

New Electronic Products

Shutoff Valve

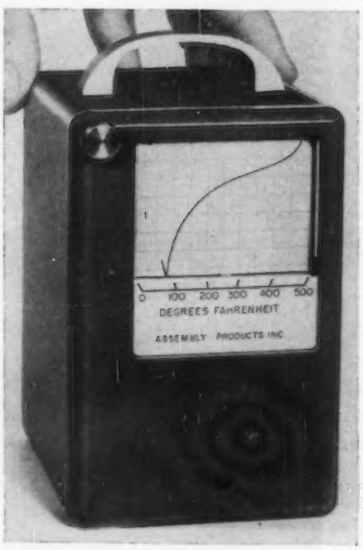
Axial flow shutoff valve will be employed for its extended operational life in a deep space probe. Metal-to-metal design to limit leakage to 1 cc. per hour was dictated by environmental requirements. Specifications: weight, 3 oz; operating pressure, 15 psi; power consumption, 2 watts; actuating voltage, 25 volt DC; size, 3/16 in. TS—Telecomputing Corp.

Circle 112 on postcard for more data

Temperature Recorder

Economical, miniaturized temperature recorder that operates directly from a thermocouple, without signal amplification. The Temprint recorder is believed to be the first available with a meter movement that is sensitive enough to permit temperature recording without a signal amplifier. The meter movement, calibrated to match the thermocouple, is essentially the same as those used in sensitive API panel pyrometers. — Assembly Products Inc.

Circle 113 on postcard for more data



only Koncentrik® STAINLESS PIPE UNIONS give you a fully confined TEFLON SEAL

Patented construction provides double sealing action. Excellent for high pressure and high vacuum applications. Pressure ratings 2,000# to 6,000#. Screwed or socket weld ends, for pipe sizes to 2". Send for catalog today.

THE SPECIAL SCREW PRODUCTS COMPANY SSP
BEDFORD, OHIO

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Automark®
MOTOR DRIVEN or HAND OPERATED
WIRE AND TUBE MARKERS
WITH SPEEDS UP TO 17,000 FEET PER HOUR

Equipped with 110 V AC Motor.
Adjustable stamping depth.
Foil feed adjustable and automatic.
Feed adjustment 1" to 18"
Accommodates wire size AN-26 thru AN-0000, and tubing from 1/16" to 1-1/2" O. D.
Heat range from 100° F. to 600° F. controlled by thermostat and thermometer.
Machine can also be supplied with automatic cut-off mechanism, bench mounting and foot pedal operation.

DEFIANCE MACHINE & TOOL COMPANY
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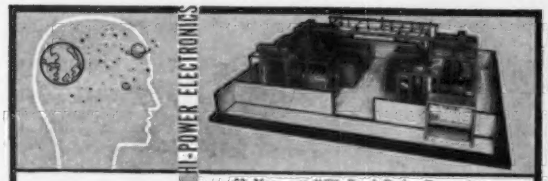

50 Megawatt "S" Band Radar Transmitter

The result of complex challenges

FXR's advanced techniques and facilities have produced the 50 Megawatt "S" Band Radar Transmitter for Cornell Aeronautical Laboratories. This transmitter, more than twice as powerful as the formerly largest unit of its class, will be used in the electronic exploration of the atmosphere and the ionosphere.

FXR has an extensive achievement record in solving demanding problems. Put this creative ability to work to help solve your High Power Electronics problem.

For detailed information concerning your particular application, contact your FXR applications engineer. He is only a phone call away.

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NOW...

SAMPLE AIR FASTER, MORE ACCURATELY, PORTABLY

Accurate to 1/100 micron!

INDISPENSABLE for series or unit air sampling – indoors or out. Portable, yet stands up to heaviest usage. Weighs only 10 lbs. Comes equipped with standard 4" filter holder. Special adapters available for 6" x 9"; 8" x 10"; 12" x 12" and others.

Staplex Air Samplers are widely used to solve the many diverse, exacting needs of leading industries. Also for industrial hygiene and health departments, nuclear and missile fields; manufacture and processing of beryllium products, radioactive materials and all other industrial dusts and air pollutants.

Let us help you solve your air sampling problems as we have for thousands of users. Send for details.

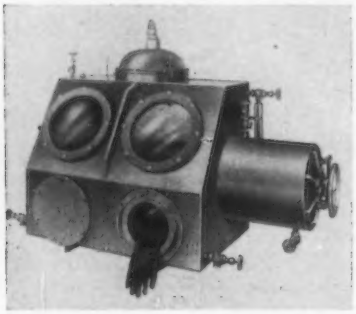
THE STAPLEX COMPANY
779 FIFTH AVENUE • BROOKLYN 32, N. Y.
World's Largest Manufacturer of High Volume Air Samplers

Circle 46 on Inquiry Card

New for Production

Lab Enclosure

New laboratory enclosures are for chemical and metallurgical research on materials under high vacuum. They are available in



standard units of 3′ and 4′ modules. Vacuum dry boxes have been tested with a mechanical pump and have been pumped down to approximately 50 microns.

Testing with the system completely blanked off and after a slight rise due to degassing has resulted in a leak rate of ½ micron per minute.—S. Blickman Inc.

Circle 114 on postcard for more data

Fast Printer

High-speed facsimile scanning and printing units can scan and transmit page-width documents of any length at a rate of 15 linear feet per minute.

The scanner, with its vacuum-ported scanning drum, accepts random length documents for scanning and then transmits the intelligence in the form of video signals to its campanion printer for either continuous or intermittent 'hard copy' print-out operation. Dry, permanent copies are produced on standard-weight paper.—A. B. Dick Co.

Circle 115 on postcard for more data

Micrometer

Micrometer permits direct measurements of internal groove and land widths in bores as small as a quarter-inch in diam. The instrument can be used to check workpieces without the necessity of removing them from the machine.

Direct-measuring, internal-width micrometers replace as many as six different conventional measuring devices formerly required to set up and check under-cut machining operations.—Navan Products.

Circle 116 on postcard for more data

Detects Flaws

Single frequency non-destructive testing equipment employs a unique oscilloscope presentation to indicate surface or sub-surface flaws in non-ferrous, non-magnetic materials. Equally adaptable to production line use, or a separate inspection operation. At inspection speeds of 50 to 600 ft. per minute, materials ⅛″ to 3″ in diameter can be inspected. — Magnetic Analysis Corp.

Circle 117 on postcard for more data

Heat Without Fuel

Plasma Torch utilizes temperatures over 3000°C. Experiments are now under way to reach 5,700°C.

None of the parts of "Plasma Torch" ever heat. The only component that will eventually have to be replaced is the electron tube or magnetron used to generate the electromagnetic field. — Amperex Electronic Corp.

Circle 118 on postcard for more data

Sealant Process

Mass production method gives positive adherence of a sealant in any elastomeric material. Eliminates after-assembly sealing.

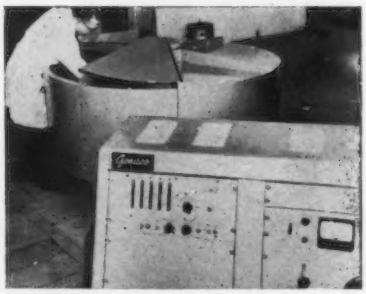
The selective placement of sealing material can be applied in almost any position, shape, or form on metal stampings, plastic parts, nuts and nut washer assemblies. — Automotive Rubber Co.

Circle 119 on postcard for more data

Acceleration Testing

Centrifuges combine the ruggedness, flexibility, fast response, and operating convenience demanded by production acceleration test programs with the accuracy required for laboratory testing.

New Model 1220 Centrifuge will subject a 150 lb, 18″ cube test specimen to g forces of from 0 to 250 g's at 24″ nominal radius. Its maximum centrifugal capacity is

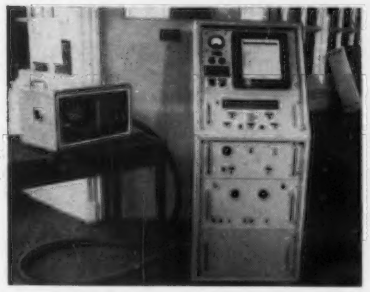


15,000 g-pounds. New Model 1230 will test a 150 lb, 24″ cube test specimen to simulated g loadings of from 0 to 200 g's at 42″ nominal radius. Its maximum centrifugal capacity is also 15,000 g-pounds.—Genisco Inc.

Circle 120 on postcard for more data

Beryllium Monitor

A Beryllium Monitor is now being manufactured and marketed. The model now available detects



aerosole containing beryllium and records the state of the atmosphere where it is placed at intervals of 60 seconds. Standing some 5 ft. high, the instrument console is connected to the detector head by a flexible air hose. This allows samples to be taken at the operator's inhalation level on any particular job or machine.—Winston Electronics Ltd.

Circle 121 on postcard for more data

Polyform Process

Polyform process is a new method of forming conetic metal enclosures. Difficult to form conetic metal can be formed into almost any shape, including reverse angles. Magnetic shielding is superior to that of standard formed conetic metals of the same weight. The expense of tooling is eliminated, thus cutting fabricating time. — Barber-Colman Co.

Circle 122 on postcard for more data

Flame Cutter

Gantry-type, multiple-head flame cutter handles plate up to 20 ft. wide up to any length. It has unlimited capacity for squaring large plate sizes, scarfing, beveling and edge preparation to close precision tolerances, and can be converted to a straight-line automatic welding rig. Gantry unit is recommended for use with two end trimmers which also travel on the rails with the gantry and provide cross-cut trimming.—Ty-Sa-Man Machine Company

Circle 123 on postcard for more data

continued on next page

TWO DIFFERENT TIPS GIVE

2 SOLDERING TEMPERATURES

Merely interchange high and low heat tips for the soldering temperature best suited for the job. Low heat for heat-sensitive soldering . . . higher heat for regular work. Available with Magnastat Soldering Iron model TC-552.

Weller MAGNASTAT®

CONTROLLED TEMPERATURE SOLDERING IRONS

- Automatically maintain correct soldering temperature
- Weigh only half as much as uncontrolled irons
- Give greater heat efficiency with lower wattage

Plus these advanced features for greater efficiency: • Various tip types now available • New tip retaining nut minimizes freezing • New rubber shock absorber prevents sliding • New, rugged, non-arcing snap switch • Handle stays cool • New cord connection locks cord securely in place, yet permits easy replacement • 2 or 3-wire cords available.

3 MAGNASTAT SOLDERING IRONS ARE AVAILABLE

MODEL TC-552. 55 watts, for heat-sensitive soldering $9.00 list

MODEL TC-602. 60 watts, for light to medium soldering $10.00 list

MODEL TC-1202. 120 watts, for medium to heavy soldering . . . . . $11.50 list

Prices shown are for Magnastat Iron with tip and 2 wire cord.

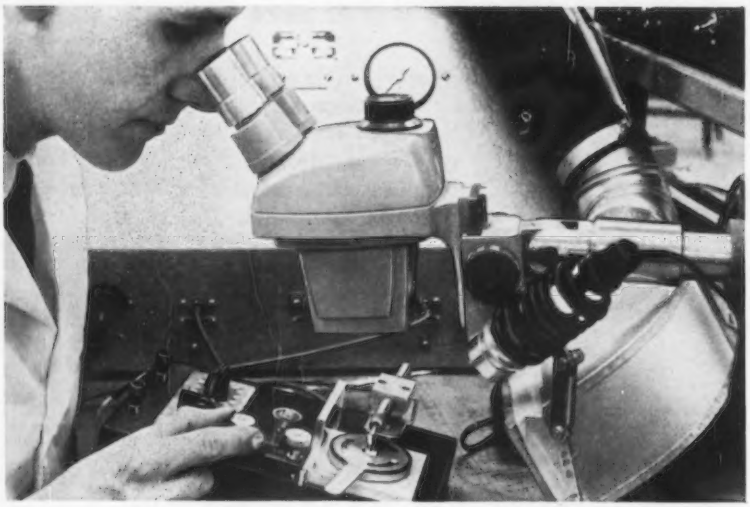
Send for NEW literature on Weller MAGNASTAT Soldering Irons.

WELLER ELECTRIC CORP. 601 Stone's Crossing Rd. Easton, Pa.

Another "impossible" job done by the Airbrasive®...

...Micromodule circuits

abrading • cutting • deburring • stripping • drilling • cleaning • scribing



Key to fabrication in RCA Basic Micromodule Laboratory...The Airbrasive cuts and adjusts micro-miniaturized components

S. S. White's Industrial Airbrasive is the key to rapid construction of Micromodules by the new RCA Basic Micromodule Laboratory.

Faster and more reliable and flexible than photo-etching methods, the Airbrasive forms circuits and adjusts resistors and capacitors by abrading away controlled portions of deposited conducting surfaces and terminations.

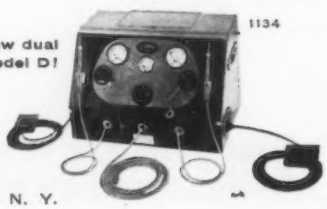
Every day the Airbrasive is solving problems that once appeared impossible. Its precise stream of superfine abrasive particles, gas-propelled at supersonic speeds, quickly slices or abrades a wide variety of hard brittle materials... fragile crystals, ceramics, thin films, tungsten... and others. No shock, no heat damage. There is no contact between the tool and the work.

Note this too. The Airbrasive is not expensive... for under approximately $1,000 you can set up your own unit.

Send us samples of your "impossible" jobs and we will test them for you at no cost.

SEND FOR BULLETIN 6006
...complete information.

New dual Model D!



1134

S. S. White

S. S. White Industrial Division
Dept. 18A, 10 East 40th Street, New York 16, N. Y.

New for Production

. . . *continued*

Tool-Changing System

Automatic tool changing system has been shown and demonstarted for the first time. System can easily be engineered into various tape-controlled single spindle machine tools. This speeds up tool changes for sequence machining operations and helps assure low cost small lot production. It changes tools in approximately 3 seconds. Key in the tool encoder allows proper selection of any one of over 65000 possible tool combinations for automatic tool change. — Scully-Jones & Co.

Circle 124 on postcard for more data

Double Disc Grinder

The Gardner 2H30 precision double horizontal spindle disc grinder loads and indexes universal joint spiders. It grinds each pair of trunnion ends flat and parallel, and automatically keeps abrasive discs dressed and advanced to compensate for wear. Automatic loading of spiders into the rotary carrier reportedly marks a "first" in grinding these parts.—Gardner Machine Co.

Circle 125 on postcard for more data

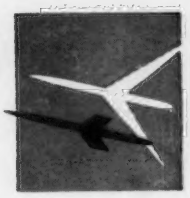
Wiring Analyzer

Automatic wiring analyzer can check up to 6,000 circuit assemblies for current continuity and leakage. Tests are controlled by programmed IBM cards corresponding to the wiring diagram of circuits being checked. One card is required for each circuit, and the machine processes 60 cards every minute.

As the cards complete their test cycle, they automatically fall into "condition of circuit" bins which classify the type of circuit failure and its location in the assembly.—Hughes Aircraft Co.

Circle 126 on postcard for more data

Worth Asking For



Vacuum Furnaces

Eight-page bulletin describes vacuum-type furnaces.—*Lindberg Engineering Co.*

Circle 127 on postcard for more data

Ordnance Devices

Explosive-actuated devices described in new catalog. — *Lockheed Electronics Co.*

Circle 128 on postcard for more data

Nylon Shapes

Eight-page brochure gives data on nylon stock shapes available from new mill source.—*Cadillac Plastic & Chemical Co.*

Circle 129 on postcard for more data

Tube Fittings

New 4-page folder illustrates and fully describes new flareless tube fitting, made in stainless steel for corrosion-resistant service.—*Parker-Hannifin.*

Circle 130 on postcard for more data

Modern Warehousing

28-page, 2-color brochure describes the facilities, policies, operating practices and services largest independent non-ferrous warehouse in the U. S.—*T. E. Conklin Brass & Copper Co.*

Circle 131 on postcard for more data

Salt Spray Chamber

Bulletin C-11-2 describes new line of all-Lucite salt spray chambers for environmental testing. — *Associated Testing Laboratories.*

Circle 132 on postcard for more data

Cold Propellant Rocket

Bulletin describes construction features, performance of recoverable atmospheric rocket.—*Texaco Experiment Inc.*

Circle 133 on postcard for more data

SNAP

Pamphlet on SNAP series of radioisotope-powered generators for power generation.—*The Martin Co.*

Circle 134 on postcard for more data

Pioneer V

Description of instrumentation, experimental measurements of Pioneer V payload.—*Space Technology Laboratories*

Circle 135 on postcard for more data

Explosive Valves

Catalog on explosive valves and latch pins.—*Conax Corp.*

Circle 136 on postcard for more data

Rocket Test Equipment

Brochure on test equipment produced by firm.—*Astrosystems Inc.*

Circle 137 on postcard for more data

Testing Equipment

Brochure, "Custom-built Production Chilling and Environmental Test Equipment."—*Cincinnati Sub-Zero Products.*

Circle 138 on postcard for more data

AVCO-Nashville

Facilities brochure gives complete picture of division's activities.—*Nashville Div., Avco Corp.*

Circle 139 on postcard for more data

Fairchild

Booklet, "Facts About Fairchild" pictures firm's operation.—*Fairchild Camera and Instrument Corp.*

Circle 140 on postcard for more data

Connectors, With Chart

Wall chart on missile system connectors includes two large color-drawings of a liquid and a solid propellant missile showing main features and place of components.—*E. B. Wiggins Oil Tool Co. Inc.*

Circle 141 on postcard for more data

CF700

Bulletin GED 4194 on CF700 aft-turbofan engine for executive aircraft.—*General Electric Co.*

Circle 142 on postcard for more data

Heat-Treat Technology

Brochure explains infrared measuring systems.—*Leeds & Northrup Co.*

Circle 143 on postcard for more data

Titanium Alloy

Booklet gives complete properties of titanium alloy Ti-8AL-IMO-IV.—*Titanium Metals Corp. of America.*

Circle 144 on postcard for more data

Silicone Modified Rubber

48-page two-color technical manual explains applications of silicone modified rubber in the Rocket and Missile Industry. Includes the various types of SMR compounds, insulation data, and plastic laminates.—*Stoner Rubber Co.*

Circle 145 on postcard for more data

EBW

Exploding bridgewire system for ordnance safety in missiles and space vehicles explained. — *Librascope Inc.*

Circle 146 on postcard for more data

RC-2525

Properties and applications of RC-2525 vinylidene fluoride resin fully described in booklet.—*Pennsalt Chemicals Corp.*

Circle 147 on postcard for more data

Nord

Brief history of French aviation and description of firm's current projects.—*Nord-Aviation.*

Circle 148 on postcard for more data

Missile Attitude

Report UNC-230 describes hydrogen peroxide reaction control systems; includes system schematic, pictures of motors used in second and third stage Scout.—*Walter Kidde & Co.*

Circle 149 on postcard for more data

Ballscrew Assemblies

Folder on precision recirculating ballscrew units for aircraft, missiles, and ground support.—*Walter Kidde & Co.*

Circle 150 on postcard for more data

O. E. G.

Folder describes Operations Evaluation Group, M.I.T.'s civilian organization offering scientists a career in military operations research.—*Massachusetts Institute of Technology.*

Circle 151 on postcard for more data

Cryogenic Subsystems

Booklet UNC-236 on Integrated Cryogenic-fueled spacecraft subsystems.—*Walter Kidde & Co.*

Circle 152 on postcard for more data

Plugs

Catalog presents description of the KQ/KR line of Cannon miniature plugs.—*Cannon Electric Co.*

Circle 153 on postcard for more data

Rupture Disks

Data on Impervite rupture disks. —*Falls Industries Inc.*

Circle 154 on postcard for more data

Wire

Wire for use in the semiconductor industry is described in new pamphlet. —*Secon Metals Corp.*

Circle 155 on postcard for more data

Angle Torch

Bulletin describes controlled angle torch for tungsten inert gas, arc welding.—*Falstrom Co.*

Circle 157 on postcard for more data

continued on next page

Worth Asking For

. . . continued

Raytheon Products

Products and services outlined by divisions producing them.—*Raytheon Co.*

Circle 158 on postcard for more data

Mobile Labs

Complete description, including equipment and chemicals, of firm's mobile test labs.—*Wyle Laboratories*

Circle 159 on postcard for more data

High Temperature Materials

Booklet on cermets with significant technical data.—*Bendix Products Div.*

Circle 160 on postcard for more data

Battery Firm

Review of firm's facilities, research, and personnel.—*The Electric Autolite Co.*

Circle 161 on postcard for more data

Plastic Research

Description of expanding fields of research for modern plastic firm.—*CTL, Div. of Studebaker-Packard*

Circle 162 on postcard for more data

Moon Map

Map of the moon with 309 geographic features.—*Missile Div., North American Aviation*

Circle 163 on postcard for more data

Liquid Rocket Oxidizers

Table of properties of liquid rocket oxidizers.—*Astrosystems Inc.*

Circle 164 on postcard for more data

Space Systems

Fully illustrated brochure shows firm's facilities and capabilities in space engineering, manufacturing, solid-state electronics.—*Aerolab, subsidiary of Ryan Aeronautical*

Circle 165 on postcard for more data

Transac S-2000

Description of all-transistor data processing system.—*Philco Corp., Government & Industrial Group*

Circle 166 on postcard for more data

Flame Cutting

Line of Oxweld flame-cutting machines described in a 28-page catalog. —*Linde Co.*

Circle 167 on postcard for more data

Slide Calculator

Vest-pocket calculator on general properties of gases.—*Liquid Carbonic Div., General Dynamics Corp.*

Circle 168 on postcard for more data

Sub-Zeroing

Folder describes one to ten cubic foot units especially designed for lab and job shop applications where temperatures from −150 to +300°F are required.—*Cincinnati Sub Zero Products*

Circle 169 on postcard for more data

Liquid Level Sensor

Folder describes unitized liquid-level switch combining an ultrasonic probe and a transistorized control into an integral unit.—*Acoustica Assoc.*

Circle 170 on postcard for more data

Motorola

Color brochure shows management setup, projects, reliability, research development and production programs, financial structure.—*Motorola Military Electronics Div.*

Circle 171 on postcard for more data

SPAN

SPAN (Semiconductor Product Applications News) contains illustrated articles on "Voltage Regulator Diode Surge Ratings" and "The Silicon Uni-Tunnel Diode."—*Hoffman Electronics Corp.*

Circle 172 on postcard for more data

Rocket Engines

Folder on firm's research rocket engines.—*Astrosystems Inc.*

Circle 173 on postcard for more data

CompuDyne

Brochure entitled "Capabilities of CompuDyne Corporation"—*CompuDyne Corp.*

Circle 174 on postcard for more data

Honeycomb

General brochure "This Is Hexcel Honeycomb."—*Hexcel Products Inc.*

Circle 175 on postcard for more data

Recording Oscillograph

Four-page bulletin contains photos and specifications on new portable recording oscillograph. — *Electro Mechanical Instrument Div., Consolidated Electrodynamics Corp.*

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Hoffman

Brochure illustrates and describes firm's equipment in navigation, communications, radar, electronic countermeasures, includes business setup and facilities.—*Hoffman Electronics Corp., Military Products Div.*

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Servomotors

Catalog shows new models and updated specs on Size 8 and Size 11 servomotors.—*Helipot Div., Beckman Instruments Inc.*

Circle 178 on postcard for more data

Resin Molding Booklet

Booklet on properties uses, and molding requirements of compounds based on Dapon diallyl phthalate resins.—*Food Machinery and Chemical Corp.*

Circle 179 on postcard for more data

Controls

Integrated control systems for aircraft and missile variable displacement hydraulic pumps described. — *Vickers Inc.*

Circle 180 on postcard for more data

GP

Engineering service organization described.—*GP Engineering Services Inc.*

Circle 181 on postcard for more data

Ultrasonic Primer

Folder explains ultrasonic cleaning; 28 page catalog shows firm's ultrasonic cleaning equipment. — *National Ultrasonic Corp.*

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Inertial Guidance

Story of AChiever all-inertial guidance system with brief working description. — *Electronics Div., General Motors.*

Circle 183 on postcard for more data

Projection Welding

Brochure "Projection Welding Low Carbon Steel with Embossed Projections" gives detailed information on projection welding techniques, projection-forming tools, welding electrodes and joint design.—*The Taylor Winfield Corp.*

Circle 184 on postcard for more data

Stand-Off Fasteners

Booklet, "What You Should Know About Stand-Off Fasteners." — *Western Sky Industries.*

Circle 185 on postcard for more data

Silicon Diodes

Literature lists new line of medium power silicon diodes. — *Controls Co. of America.*

Circle 186 on postcard for more data

Flame-Plated Coatings

Up-to-date physical data and characteristics of Flame-Plated coatings.—*Linde Co., Div. of Union Carbide Corp.*

Circle 187 on postcard for more data

Electron Beam Welding

New electron beam welding unit described.—*Air Reduction Sales Co.*

Circle 188 on postcard for more data

Adhesives

Booklet on bonding and testing of adhesives. — *Raybestos- Manhattan Inc.*

Circle 190 on postcard for more data

PCM

Bulletins on "Astro" PCM systems.—*Epsco Inc.*

Circle 191 on postcard for more data

Stainless Steels

Bulletin on firm's cold-rolled stainless strips, and production facilities. —*Rodney Metals Inc.*

Circle 192 on postcard for more data

Magnetic Separators

Bulletin on high pressure magnetic separators for hydraulic systems.—*S. G. Frantz Co.*

Circle 193 on postcard for more data

Transfer Lines

Folder on vacuum-jacketed transfer lines for transfer of low temperature liquid oxidizers. — *Rochester Div., Consolidated Electrodynamics.*

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Men on the Move

Quentin G. Turner
Motorola

QUENTIN G. TURNER, placed in charge of all managerial aspects of development and production of the Mission and Traffic Control system for the B-70, at Motorola Inc.

WILLIAM L. DAVIS, appointed manager of Army and Navy Sales for the Missile and Space Vehicle Dept., General Electric Co. A. T. CHRISTENSEN, appointed manager of sales and contract management for the department.

Carroll J. Peirce
Goodyear Aircraft

CARROLL J. PEIRCE has joined the office of the Chief Engineer at Goodyear Aircraft Corp. CHARLES D. CONNER has joined Goodyear as a development engineer in the firm's computer engineering department.

DR. RICHARD P. CARTER, appointed technical superintendent at the Rocky Hill plant, Hercules Powder Co.

JOHN P. BUTTERFIELD, named executive engineer on the corporate staff of The Martin Co.

J. L. BROMBERG, appointed director of programs — defense programs, at Douglas Aircraft Co.

DR. R. H. MCFEE, named director of research at Aerojet-General's Azusa plant.

Roy P. Jackson
Aeronutronic

ROY P. JACKSON, appointed manager of the marketing staff, Aeronutronic Div., Ford Motor Co.

CHARLES S. HAZARD has joined American Machine & Foundry Co. as manufacturing specialist. LEON A. MENZL, JR., has joined AMF as procurement administrator.

EUGENE L. WOODCOCK, appointed to the senior technical staff of the Electro-Optical Div., Perkin-Elmer Corp., Los Angeles.

Socrates N. Vavoudis
Norden Div.

SOCRATES N. VAVOUDIS has joined United Aircraft Corporation's Norden Div. as supervisor of the environmental laboratory.

CLYDE A. FORD, appointed manager of material at Convair - Ft. Worth.

SERENUS H. A. YOUNG, named general manager of the Hunter Bristol Div., Thiokol Chemical Corp.

DR. HENRY E. SINGLETON has joined Amelco, Inc. as president.

ROBERT B. KATROV, named manager of tactical missile systems at Aeronutronic.

Robert B. Katkov
Aeronutronic

J. V. NAISH, president of Convair, has been elected Chairman of the Board of Governors of the Aerospace Industries Association for 1961. H. M. HORNER, chairman, United Aircraft Corp., was named vice chairman of the Association.

DR. HENRY SWIFT, appointed assistant director of the infrared laboratory at Hughes Aircraft Company's Santa Barbara Research Center.

ABRAHAM HYATT, named director of NASA's Office of Program Planning and Evaluation.

ROBERT D. ROCHE, named aerospace development sales manager with Lockheed Aircraft's Georgia Div.

MARION MAXFIELD has joined Vertol Div. of Boeing Airplane Co. as manager of commercial programs. FRIEDRICH L. DUBLHOFF, appointed corporate director of engineering, Europe.

RAYMOND H. HELLER, appointed general manager of Robertshaw-Fulton's Aeronautical and Instrument Div.

BILL M. LANE appointed manager of the newly organized western operations of Vitro Engineering Corp.

WARREN B. RILEY holds the new post of director of marketing and commercial product planning for The Bendix Corp.

JAMES B. CONSTABLE, now manager of the new Lockheed Georgia Div. aerospace office in Sunnyvale, Calif.

PATRICK W. TIMBERLAKE is the newly-appointed head of Northrop's International Division.

J. L. ATWOOD, president of North American Aviation, named chief executive officer of the company.

R. S. ERICKSON appointed director of the Polaris Computer Program at Control Data Corp.

JACK DURST, named associate technical director of the Pomona Division of The Marquardt Corp.

GINO E. DEPAOLA, appointed senior staff engineer at John Gombos Co.

RICHARD B. UHLE, named to the newly-created position of assistant general manager of Avco's Electronics and Ordnance Div.

E. F. BROWN, named vice president of administration at Rocketdyne.

J. V. Naish
Convair

Robert D. Roche
Lockheed-Georgia

Raymond H. Heller
Robertshaw-Fulton

Patrick W. Timberlake
Northrop

Gino DePaola
John Gombos Co.

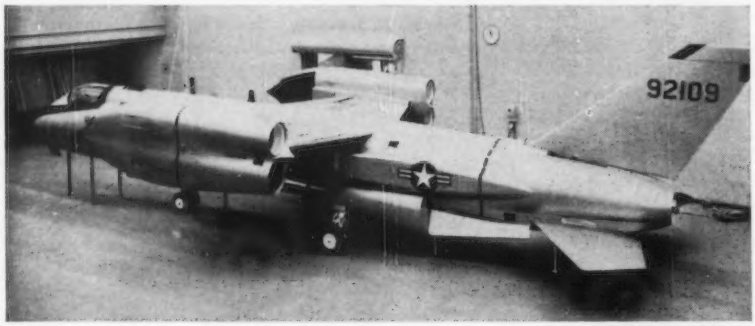
Industry Notes

VTOL/STOL Advances

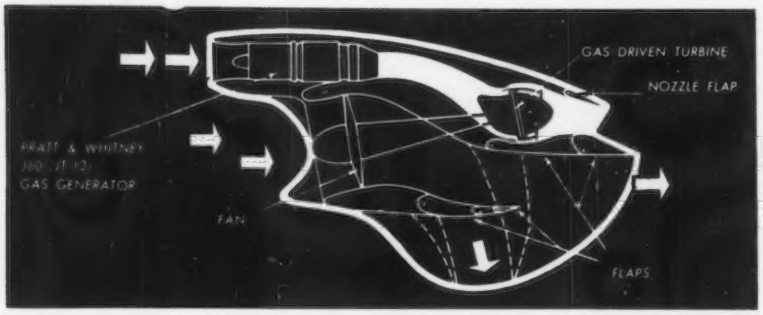
The Aerospace Industry's VTOL/STOL research should result in new operational types within the decade. Recent developments include:

- Hawker Aircraft's P.1127 completed hovering trials. These included hovering free from any ground restraint, though the VTOL/STOL fighter was usually tethered to a test rig. Design modifications are expected before a configuration is submitted to NATO for competitive trials.
- Bell Aerosystems revealed its previously-secret design for a Mach 2.3 jet fighter-bomber. According to the firm, D-188A aircraft could take off vertically and complete transition to horizontal flight in 60 sec. D-188A could reportedly complete vertical landing in about the same time span. The services are now managing a joint program for developing a supersonic VTOL by the late 1960's.
- Chance Vought's Aeronautics Div. revealed details of its ADAM propulsion/control system for VTOL/STOL logistic transports.

HAWKER P.1127 has completed hovering tests at Dunsfold, Surrey. It is designed around the BS.53 lift thrust engine.

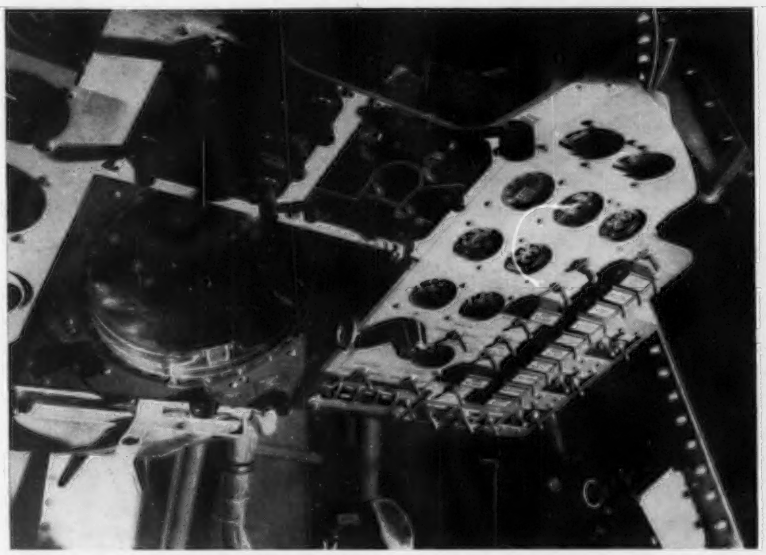


DI88A MODEL, recently unveiled by Bell Aerosystems Co., is designed as a Mach 2 VTOL fighter-bomber powered in forward flight by four wing-tip J85 turbojets and two rear fuselage J85's. Wing-tip engines are rotated to a vertical position for takeoff and landing.



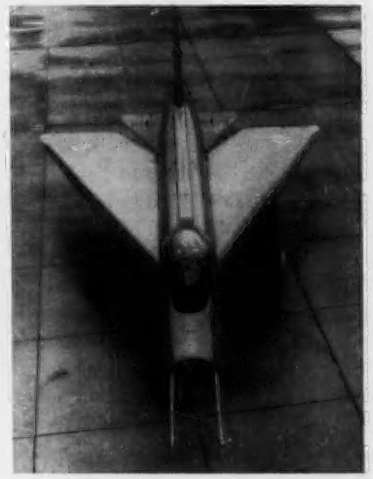
ADAM CONCEPT has been advanced by Chance Vought for the VTOL/STOL logistic transport field. Four J60 Pratt & Whitney engines, located in pods above wing, drive paired turbofans on either side of fuselage. Flaps on wing trailing edge divert this airstream down for vertical rising, back for forward flight. Model of ADAM (Air Deflection and Modulation) plane has been wind-tunnel-tested.

AIRFLOW from fans in ADAM merges into one stream in cold gas duct, then exits through rectangular nozzle at trailing edge of duct.



MERCURY INSTRUMENT PANEL is duplicated in training device at NASA's Space Task Group. Three dials at top center show pitch, roll, and yaw attitude. Two "blocks" beneath them contain earth path indicator and clocks. Periscope is at bottom. Environmental system dials and warning nameplates are to the right.

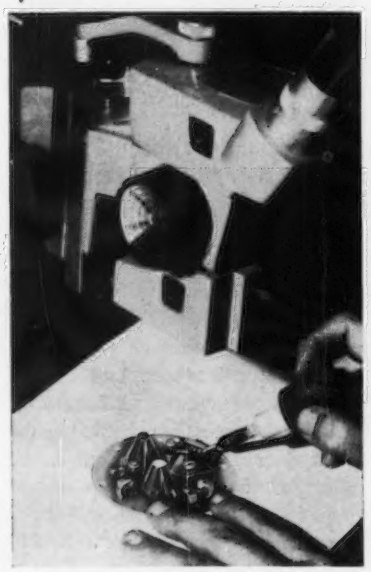
SHORT SB.5 research aircraft recently resumed flying with a sweep angle of 69°. It was developed by Short Brothers & Harland Ltd., Belfast, N. Ireland.



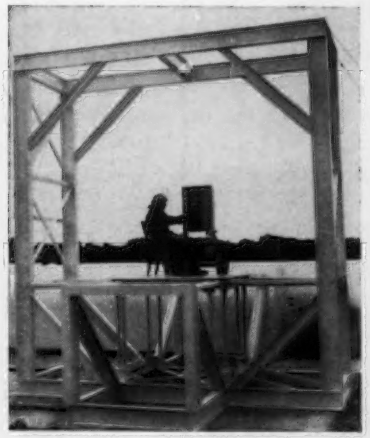
R & D Pictorial

TWO-CHANNEL RADIOMETER in Tiros II weighs about 1½ oz, measures Earth's temperature and efficiency in absorbing solar radiation. Orbited Nov. 23, satellite has TV cameras which have transmitted cloud photos.

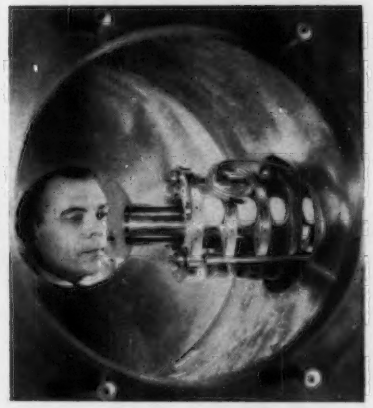
▼



ION ENGINE MODEL at Goodrich-High Voltage Astronautics Inc. ▶ is installed in vacuum tank for testing.



HUMAN SHOCK TESTING tests ability to stand effects of near misses of thermonuclear bombs on missile hard sites. Special equipment was rigged by American Laboratories Div., American Electronics Inc.



TIROS II TESTS of satellite's new magnetic stabilization system took place inside spherical cage designed to simulate Earth's magnetic fields.

Industry Notes

. . . continued from page 94

R & D Briefs

New aircraft electronic system developed by Hughes Aircraft enables a fighter-bomber to fly hedge-hopping missions in adverse weather and to avoid detection by darting in below an enemy's radar cover. Called TARAN (Tactical Attack Radar and Navigator), system will make it possible for tactical aircraft to operate by electronic control. It includes a "terrain avoidance" mode. "Ground mapping" is another feature designed to aid blind flying. In this mode the radar scope displays a "picture" of the terrain beneath the aircraft so the pilot can orient himself and compare the radar picture to the navigation map-display.

Technical guides for designing Mach 5 swept-wing aerospace vehicles are being developed under an 18-month $1-million research program at Aerojet-General.

Gliders with over 10,000 lb capacity providing capability for transport of the new space age rocket stages such as the large multi-engine Saturn have been proposed by the Lockheed Missiles and Space Div.

Satellite mail relay has been accomplished using Echo as a relay station. Project was managed for the Post Office Department by Adler Electronics.

Thrust vector control of the Navy's Polaris is under study at General Electric's Aircraft Accessory Turbine Dept. Studies will determine the feasibility of utilizing a lightweight pneumatic-powered gas servo system for fast, precise position control during flight.

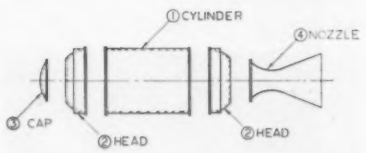
Improved welding techniques for super alloys are being sought by Republic Aviation Corp. under Air Force contract. Study is expected to provide solutions to welding problems that occur in connection with iron and nickel based alloys.

"Missile bloom" effect, occurring shortly after launch of a ballistic missile, is being studied by The Research Div. of Radiation Inc. "Bloom" appears as a whitish glow surrounding the missile at night, has a rapid growth that persists for many seconds, and has a diameter of several miles.

Azusa Mark II advanced missile tracking system is now in use at the Air Force Missile Test Center. Designed and built by Convair, it permits the Air Force to track missiles fired down the Atlantic Missile Range and to predict their impact points. Earlier Azusa Mark I system is slated for retirement in June.

8:03 To The Moon

The U. S. could put a man on the moon by 1967 with a giant, all-solid fuel, according to H. L. Thackwell Jr. of the Grand Central Rocket Co. This would beat the



slated trip to the moon by liquid fuel rockets by several years.

Proposal suggests construction of a five-stage solid rocket. Its first component would be a large cylindrical segment designed for easy shipment. Only other major parts: a combustion chamber head designed to fit either end of the basic motor segment, a head cap, and a nozzle. Two basic motor designs, one for the top stage, the other for the lower stages, would each follow this "building block" approach.

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Production Techniques

Automatic checkout system for the Saturn booster will be developed initially by The Packard Bell Electronics Corp., Technical Products Division, Los Angeles, Calif. It will largely replace the manual checkout equipment and procedures now in use at the George C. Marshall Space Flight Center.

New concept in magnetohydrodynamic (MHD) power generation for space applications has resulted from research and development conducted at Thompson Ramo Wooldridge Inc., Tapco Group. This is the "Vortex MHD Power Generator," a compact power source which can be designed to operate at a few kilowatts or at a high power source. Possible applications include emergency power for manned space vehicles, intermediate duration power (one to two weeks) and special requirements for short repetitive bursts at extremely high power outputs.

Bullpup mission simulators are now being used by the Navy. The simulators, designed and developed at Radiation Inc., are equipped with read-out devices which automatically display the pilot's "miss-distance" at conclusion of each simulated mission. Firm recently delivered the Ground PCM/FM Telemetry System for the Minuteman program to the Autonetics Div., North American Aviation.

Columbium closed-die forging has been made from a 1300 lb ingot 15 inches in diameter and 26 inches long at Wyman-Gordon. It was produced by electron beam melting followed by duplex vacuum arc melting to remove impurities. Forging procedure involved ceramic spraying of the metal to prevent absorption of atmospheric gases at forging temperatures in the 2100°-2250°F range.

Polaris missile heads are given their final contours in a specially designed explosive die, at the Edwardsville (Ill.) plant of Propellex Chemical Div., Chromalloy Corp. A head, made of high-nickel, low-chrome alloy AMS 6434 steel, is hot-preformed. Without stress relieving or annealing, it is loaded into the open die. The die is filled with water, and carefully designed charges are set off in strategic locations. Heads are 54" in diameter.

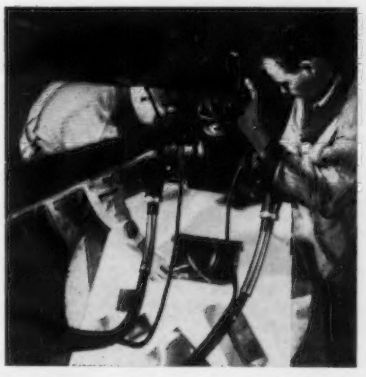
New Standards Set For Airframe Castings

Radiographic inspection guides for new light steel castings are being assembled in a standard reference manual for the entire castings industry.

The manual will include reference radiographs which will illustrate common defects. The Bureau of Naval Weapons is directing the project, requested by aero/space manufacturers. No radiographic standards have existed for sections with thicknesses of less than 0.75 inches.

Radiographs for the manual are being produced at American Brake Shoe Company's Mahwah, N. J., Research Center, for the Naval Ordnance Lab. Contract calls for the production of defective castings with walls ranging from 0.13 to 0.75 inches in diameter. The 8 in. x 6 in. castings will include following alloy compositions: 4130 or 4140, 4330, 4340, 347; 410 or 430, 17-4PH.

Each casting must contain only one type of defect. The defects will include inclusions, cold shuts, shrinkage, cracks, gas holes, hot tears, misruns.



X-RAYS of defective steel casting will become radiographs in Navy's new manual.

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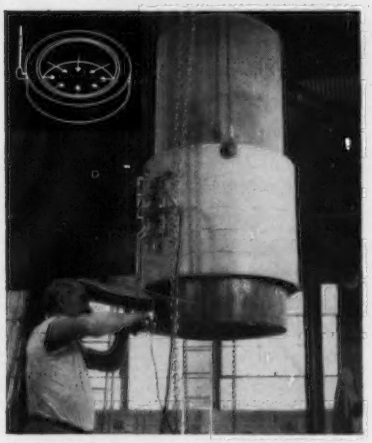

Photo courtesy Frenchtown Porcelain Co.

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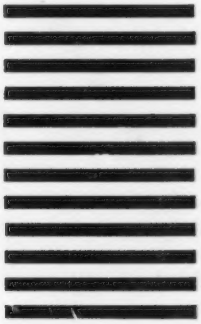

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IMPORTANT MUST INFORMATION

YOUR NAME .....**TITLE** .....

COMPANY .....

PLANT ADDRESS .....

CITY .....**ZONE**.....**STATE**.....

Please check in A & B below (one each) which best describes:

A. Your Job Function

....1. Management
....2. Design & Engineering
....3. Production
....4. Procurement

B. Type of Plant or Facility

....1. Airframe
....2. Propulsion
....3. Electronic Systems & Parts
....4. Mechanical Systems & Parts
....5. Raw & Processed Material
....6. Engineering & Research Services Facilities
....7. Military & Government
....8. Parts & Supplies
....9. Plant or Test Equipment
....0. Other

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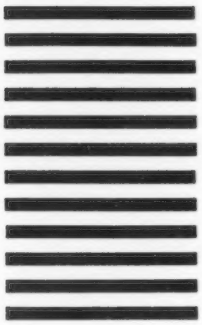

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- ....7. Military & Government
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- ....0. Other

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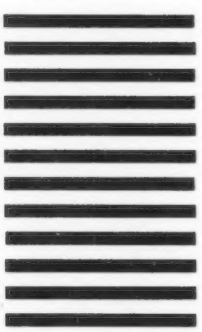

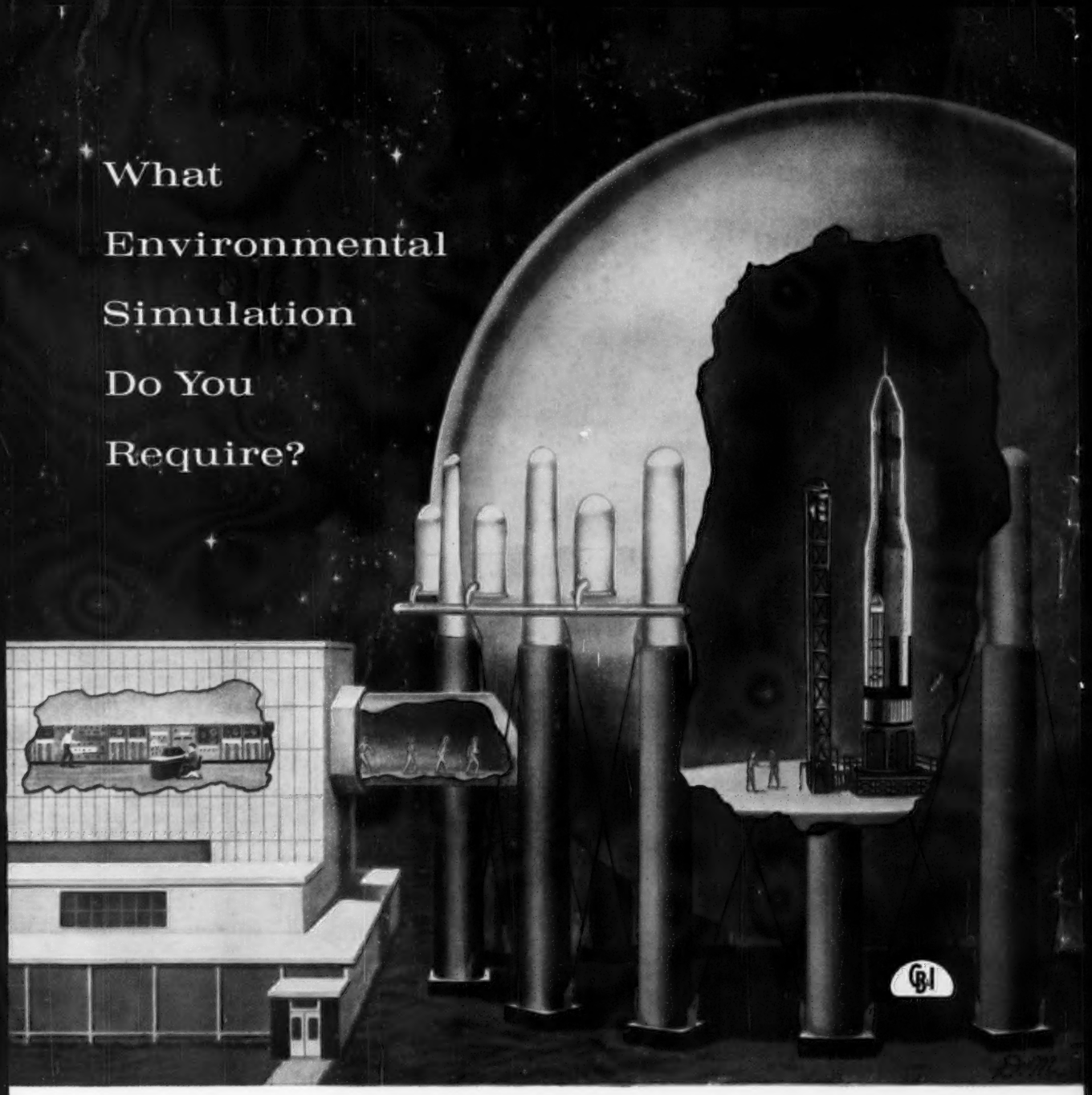

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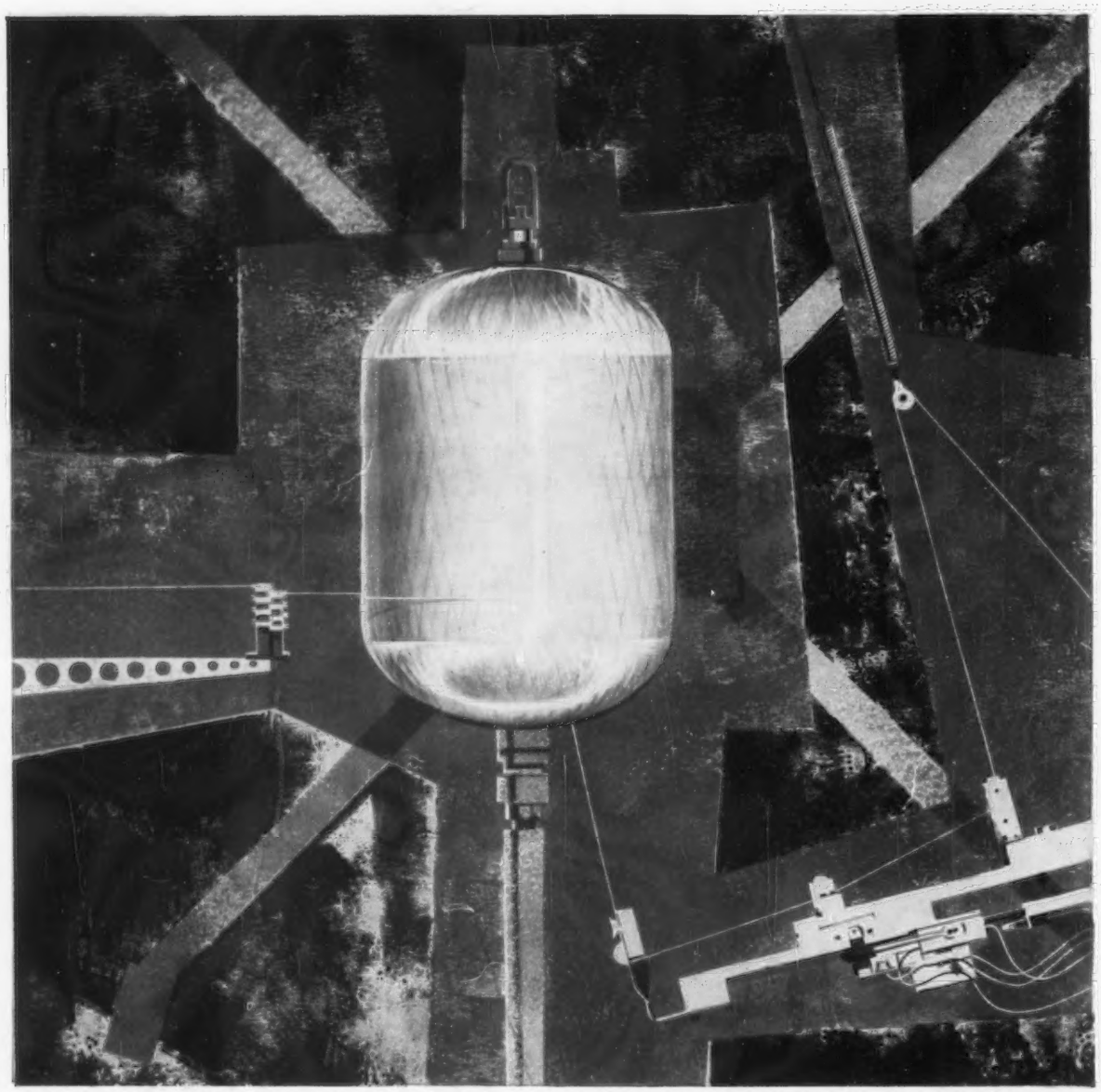

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